EMBODIED ENGAGEMENT WITH NARRATIVE: A DESIGN FRAMEWORK FOR PRESENTING CULTURAL HERITAGE ARTIFACTS WITH DIGITAL MEDIA

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EMBODIED ENGAGEMENT WITH NARRATIVE: A DESIGN FRAMEWORK FOR PRESENTING CULTURAL HERITAGE ARTIFACTS WITH DIGITAL MEDIA

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[To my husband Hyunwoo Park and my daughter Jimin Park]

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SUMMARY

This dissertation examines how digital media and physical installations can be developed and used in cultural history museums. It proposes a narrative design framework for tangible and embodied interaction to engage visitors with the cultural context of artifacts on display. The dissertation examines the literature on tangible and embodied interaction in museums, interactive narrative experience, and concepts of embodiment to build arguments about interactors' tangible and embodied interaction with narrative as a way of taking part in and relating to that narrative. It examines museum and non-museum projects that show how digital media, embodied interaction, and narrative can be integrated. Studying existing projects highlights the need for a comprehensive framework that can be used to analyze and map the design space of tangible and embodied interaction. The dissertation proposes the *Tangible and Embodied Narrative Framework (TENF)* consisting of three spectra: *internal vs. external, ontological vs. exploratory, and diegetic vs. non-diegetic*, describing the narrative perspective, interaction with plot, and the physical mode of interaction, respectively. The dissertation presents the design and development of two case study projects, the *Mapping Place* and the *Multi-Sensory Prayer Nuts*, and demonstrates how the *TENF* can be used to understand design decisions. Examination of the two case studies in light of the proposed *TENF* helps generate design considerations for digital applications to provide museum visitors with tangible and embodied interactions and support interpreting artifacts based on their cultural context.

CHAPTER 1. INTRODUCTION

Museum exhibitions throughout the world have always used stories as powerful media through which they share knowledge of history and culture in ways that empower visitors to discover meaning that they find important. In her book, *The Art of Museum Exhibitions: How Story and Imagination Create Aesthetic Experiences,* Bedford (2014) asserts that museum exhibits employ narrative experience with imagination to support visitors' personalized interpretations. She states:

> For the particular medium of exhibitions, the integration of imagination with aesthetic experience is especially appropriate. The language of the arts can also be the language of exhibitions: objects rich in meaning; stories that evoke emotions such as empathy; metaphorical play to forge new connections; design that melds space, light, image in one integrated experience. An aesthetic approach can capture and inspire the deepest kind of personal meaning making, with its potential for transformation. (Bedford 2014: 16)

Through narrative, visitors imagine other cultures and worldviews. Rounds (2006: 142) states that museums provide "a perfect setting for public performances of identity. It is a space designed for the display and performance of meaning." In museums, we empathize with other people's lives and go through transformative experiences to not only learn from others, but also expand our understanding about ourselves. Indeed, museum exhibitions display stories of other cultures and lives so that visitors can "flirt with alternative ways of being" and broaden their life trajectory (Rounds 2006: 146).

1.1 Background of the Study

Media engage visitors with the narrative around artifacts and empower them to make meaning. In tandem with developments in technology, museums have been actively employing media and physical installations – dioramas, full-size reenactments, audio guides, video projection, to digital applications – that bring interactive, sensorial, and experiential elements to their exhibits to enhance visitors' engagement with cultural heritage artifacts and practices. The goal of such firsthand experiences is not only to emotionally and intellectually engage, but also to encourage visitors to take active roles for individualized takeaways (Perry 2012).

Today's digital media (i.e., interactive tabletops, mobile applications, augmented or virtual reality applications, interactive video installations) have transformed how narratives in a museum are communicated with visitors through interactivity. Interactive media have complemented the materials museums provide to visitors: Audio guides have been complemented by interactive mobile applications, and dioramas have been complemented through high-quality interactive videos. Compared to audio guides that restrict visitors to following a pre-designed path, mobile applications help visitors choose their own paths of interest. That is, visitors choose their own routes, and interactive experiences draw each visitor to a unique entry point. Furthermore, visitors may take part in an interactive system (i.e., artifacts or installations on display) by playing roles as that system provides them with firsthand experience of an event. These ways of interaction suggest that technological interventions engage visitors with an interactive system; that is, visitors are no longer passive spectators, but can be motivated to become active participants (Perry 2012).

Tangible and embodied interactions (e.g., object-based, gestural, full-body) that integrate real-world objects or physical interactions with computational resources through the use of embedded digital media (Hornecker & Buur 2006), have been widely explored to offer hands-on museum experience to visitors. Such interactions enable visitors to access information through gestures or objects that resemble the original artifacts or cultural practices (Bannon et al. 2005; Petrelli et al. 2013). Tangible interactions have been recognized for their potential to support conversations in a collaborative environment (Hornecker & Burr 2006), to promote a sense of discovery and curiosity (Ciolfi & McLoughlin 2012), and to promote collaborative learning (Antle et al. 2011).

1.2 Statement of the Problem

Many museums that showcase cultural practices and heritage function as ethnographic museums. In addition, any public spaces, such as libraries or historic sites that share cultural heritage through cultural concepts, artifacts, or installations can also be identified as ethnographic museums. Whereas museums display artifacts in their collection behind glass cases to be cherished for their visual appearance, these artifacts were not originally intended for display, but for particular usages within a specific culture to which they used to belong. This type of display of artifacts without physical contact with them and without meaning attached to them lacks context and narrativity, thus stripping the artifacts of any meaning (Pye 2016).

Although the current forms of display in museums provide the context of artifacts through descriptive texts, images, and audio/video guides, this information is still physically separated from the visitors and different from how the artifacts would have

been experienced in practice within their cultural context. Museums often employ forms of dioramas or panoramas to represent and realize historic scenes in a dramatic way in order to place these artifacts within their original context. They use full-sized reenactments, props, video and audio guides, to give additional contextual information on how these artifacts were made and used; yet, these types of display of information still leave visitors separated from the artifact as passive spectators.

This dissertation focuses on the presentation of artifacts in ethnographic and cultural history museums. Museum displays appear to only place artifacts in their context in order to properly construct their meaning, but they do not consider how they can mediate visitors' imaginations to connect to different cultures. Cultural artifacts contain narrativity pertaining to how artifacts were used by people at a particular time and place, and they transmit cultural memory to onlookers (Bal & Marx-MacDonald 2002). While artifacts can tell stories of the people and their culture, going even further, they serve as a venue through which one can enter into and experience another culture. Artifacts and their narrativity can be an effective tool for imagining different perspectives, exploring the boundaries of different times and places. Through the narrative of artifacts, we can virtually connect to another person or a place, which we may not be able to reach in reality.

However, it is unfortunate that the current forms of display in museums do not fully appreciate the narrativity of artifacts. Morris (2014) laments that while artists and writers acknowledge the imaginative power of museums, not enough museums actually bring visitors' experiences to the imaginative realm. Ethnographic museum displays are not able to activate visitors' imaginative power because artifacts are not exhibited in their

cultural and experiential contexts; as a result, visitors cannot fully engage with artifacts and make meaning of them. Dudley (2013) has criticized museum displays for being largely ocular-centric, without offering sensory engagement with the artifacts. They simply showcase artifacts and provide information on a separate layer. Through a museum experience with enhanced experiential elements, museums can provide an engaging emotional encounter with artifacts to visitors and allow them to cherish their narrative powers. Although museums have tried to address the above-described problem with the use of digital media, they divert visitors' attention away from the actual content, requiring visitors to learn how to deal with the interface, which takes extra time and effort that could be spent on reflecting on and gaining a true understanding of the content (Hornecker 2008). Thus, it is necessary to investigate designs to be able to provide interactivity with artifacts and content that do not only focus on the historical significance of the artifacts, but also enhance visitors' interactive experiences.

1.3 Objective of the Study and Research Questions

This study investigates the design space, design methods, and effects of tangible and embodied narrative interaction design of cultural heritage artifacts in cultural heritage museums to further the discussion about the design of digital technologies (i.e., interactive tabletops, augmented or virtual reality applications, interactive installations) that enable museum visitors to engage with cultural heritage artifacts. The objective of the study is to design an interactive system using tangible and embodied interaction design principles to better engage visitors with the cultural context of the artifacts so that they can make contextualized meaning from their museum experiences.

To meet my research objective, I developed the following research questions: How can tangible and embodied interaction influence narrative engagement and how can this knowledge be applied for interaction with cultural heritage? This question can be broken down into the following research questions:

RQ (1) How can concepts of embodiment help us think about interactive narrative engagement?

RQ (2) How do tangible narrative systems integrate digital media and embodied experience to provide narrative engagement?

RQ (3) How can tangible and embodied interfaces and interactive narratives be combined to engage visitors with the cultural context in museum installations?

1.4 Methodology

Broadly, this work uses mixed methods to provide evidence about how tangible interactions can be designed to engage visitors with the cultural heritage of artifacts. It involves the following steps:

(1) close reading of the literature on interactive narrative scholarship and concepts of embodiment to examine the theoretical background; and

(2) investigation of related existing non-museum and museum projects, which lead to

(3) the development of a framework; and

(4) the design, development, iteration, & evaluation of two case study projects, leading to

(5) the generation of design considerations.

Designing tangible and embodied experience based on the *Tangible and Embodied Narrative Framework (TENF)* I propose for digital media use in museums can promote interactors to participate in and interpret cultural heritage from firsthand experience. Figure 1 shows the iterative research process in which the design and development of the case study projects are informed by the framework, but also provide feedback to revisit the framework, and also the design considerations.

This dissertation answers RQ (1) through close readings of digital media scholars, embodiment, and RQ (2) through examining existing museum and non-museum projects that offer tangible and embodied interactions with narrative. It answers RQ (3) through the design, development, iteration, and evaluation of the two case study projects. The evaluation of the case study projects using the *TENF* informs design considerations for designing interactive systems that enable museum visitors to have tangible interactions with cultural heritage and practices.

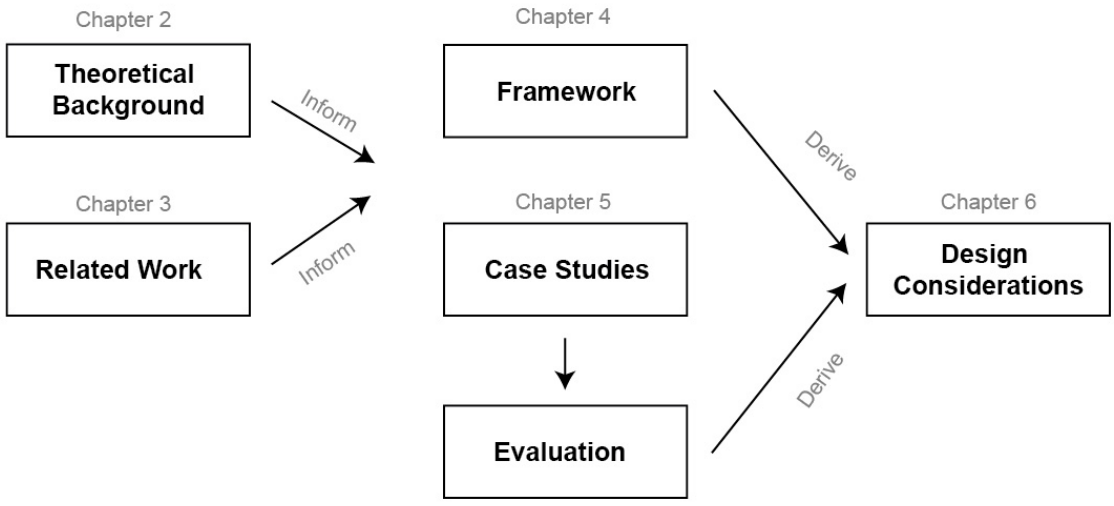

Figure 1. Research diagram

1.5 Significance of the Study

With cultural history museums presenting culturally distant information, narrative engagement through embodied interaction through the use of digital media can offer ways for visitors to imagine the cultural context of artifacts and construct their meaning by personally relating to their cultural context. The design of a museum exhibit can be informed by examining digital media systems that provide narrative experience. Digital media systems show how digital media, embodied interaction, and narratives can be integrated to reinforce or alter the interactor's narrative engagement and interpretation. Thus, examining digital media systems informs the design space for tangible and embodied experiences with cultural heritage through interactive systems in museums.

1.6 Definitions of Terminology

1.6.1 Narrative

Through oral, visual, or written forms, stories have been told in various types of media. Chatman (1980) distinguishes between a story discourse, in which the story is about the raw materials of all of the events, while the discourse describes the ways and order in which the events are presented to the reader. Bordwell and Thompson (2004), who studied film, identify how a *narrative*, a chain of events in a cause-and-effect relationship occurring in time and space, can be presented utilizing a specific medium. In this dissertation, I focus on how a *narrative* is presented through tangible and embodied media.

1.6.2 Interactive Narrative

Digital media such as mobile applications, web applications, or digital games have transformed stories to be told in an interactive format. In *interactive narrative*, interactors create or influence a dramatic storyline through their actions (Riedl & Bulitko 2012). While non-interactive narrative cognitively involves readers to imagine and interpret its meaning, interactive narrative offers interactors an active role to play and participate in the story. In this dissertation, I broaden the notion of *interactive narrative* to include various tangible and embodied experiences beyond screen-based media, which extend to our physical space (e.g., Gorbet et al. 1998; Mazalek et al. 2002; Tanenbaum et al. 2010). I include interactive installations, tangible and embodied interfaces, and augmented and virtual reality applications, and more when examining tangible and embodied interactive narrative.

1.6.3 Narrative Engagement

The term *narrative engagement* describes how interactors mentally and physically invest in and relate to the story and make narrative interpretations. This narrative engagement can be offered through various interactive narrative experiences for the interactor, such as role-play as a protagonist, narrative construction determining a story line, embodied experiences of the narrative environment, and more.

1.6.4 Diegetic and Non-Diegetic

Bordwell and Thompson (2004) refer to the Greek word, *diegesis*, to describe how a story is recounted. They refer to things like props, which exist in the fictional world as *diegetic* elements; and to things like the subtitle or background music, which the audience sees and hears but come from outside the story as *non-diegetic* elements. In this dissertation, I utilize the terms *diegetic* and *non-diegetic* to describe how tangible and embodied experiences can have a narrative reference.

1.6.5 Tangible and Embodied Interaction

Tangible and User Interfaces (TUI) have been proposed as a research domain to move beyond the graphical user interface paradigm and augment the real physical world by coupling digital information with everyday physical objects and environments (Ishii & Ullmer 1997). While the notion of "tangible interface" is restricted to physically representing data, the concept of "tangible interaction" encompasses a broader scope than tangible interfaces, denoting systems that rely on embodied interaction, tangible manipulation, physical representation of data, and embeddedness in real space (Hornecker & Buur 2006). This non-restrictive view of tangible interaction emphasizes richness of bodily movement that enables gestural and expressive interactions. The

concept of "embodiment" has influenced Human Computer Interaction (HCI) studies to describe how active bodily experiences shape how we interact with the world to make meaning of it. "Embodied interaction" focuses on how a human interactor engages with an interactive system to create and communicate meaning through one's interactions with the system (Dourish 2001). Embodied interaction extends beyond tangible and physical interaction and focuses on the situatedness of interaction in real time and real space.

In this dissertation, I use the term *tangible and embodied interaction* to encompass these various approaches — tangible interfaces, tangible interaction, and embodied interaction. When discussing tangible and embodied interaction, a variety of interfaces are included: interactive tabletops and surfaces, interactive screens, physical devices, gestural and haptic interfaces, augmented and virtual reality environment, and more, that offer a range of tangible and embodied interactions with digital media.

1.7 Organization of the Dissertation

This dissertation continues with the following sections. Chapter 1 identifies tangible and embodied interaction with cultural heritage as a problem space and shares the objective and significance of the study, motivation, research questions, and methodology of the study.

Chapter 2 presents background research in tangible and embodied interaction design in museums with perspectives from interactive narrative. It examines interactive narrative scholars and concepts on embodiment to identify how embodied experience provides narrative engagement.

Chapter 3 reviews tangible narrative systems to identify design elements and methods for a narrative experience. It presents several examples of related projects that show the way technology can integrate the story, interactive environment, and bodily interaction. It examines both museum and non-museum projects to provide a broad overview of the domain. Studying existing projects highlights the need for a framework to describe various projects and provides the framework for tangible and embodied experience with narrative to inform on cultural heritage.

Chapter 4 proposes a *Tangible and Embodied Narrative Framework* adapted from Ryan (2015; 2006) that can guide and analyze the design of tangible narrative systems and maps existing projects through the proposed framework. Adapting Ryan's (2015; 2006) framework was found to be helpful to provide an additional element for physical experience.

Chapter 5 presents two case study projects, *Mapping Place,* and *Multi-Sensory Prayer Nuts,* exemplify the knowledge gained through the framework proposed in Chapter 4.

Chapter 6 discusses design consequences of the two case study projects using the *Tangible and Embodied Narrative Framework.* Based on the evaluation of the case study projects and analysis, design considerations are shared.

Finally, Chapter 7 concludes the document with a discussion of the research contributions of this dissertation and suggestions for future research.

CHAPTER 2. THEORETICAL BACKGROUND

This chapter reviews the literature investigating the domain of museum interactions between visitors and artifacts, interactive narrative, and embodiment to provide background for this dissertation on design for tangible and embodied interaction with narrative in museums. Section 2.1 examines how museums have provided tangible interaction for *cognitive impact, sensory-motor engagement,* and *support of narrative imagination*. Section 2.2 investigates the *dramatic*- and *cognitive approaches* to narrative as described by interactive scholars (Murray 2017; Ryan 2015; 2006). Section 2.3 provides background from studies on embodiment to develop my arguments about tangible and embodied interaction as participating in and relating to a story which evokes narrative interpretation.

2.1 Tangible and Embodied Interaction in Museums

One of the goals of this dissertation is to understand how museums provide tangible and embodied interaction with cultural artifacts to support visitors' meaning-making. Using tangible embodied interaction in museums aims to achieve the following three goals: (1) *cognitive impact*, (2) *sensory engagement*, and (3) *narrative imagination*. These are briefly discussed below.

2.1.1 Cognitive Impact

Museums have identified hands-on experience as an important way to support the cognitive process of meaning-making. Researchers in *constructivism* and *constructionism* suggest that handling physical objects that embody abstract concepts supports the

thinking process. Piaget developed the concept of '*constructivism'* to explain how children learn and develop an understanding of the world through their physical experiences (Ackermann 2001; Piaget 2013). Expanding on constructivism, Papert (1980) proposed the concept of '*constructionism,'* claiming that making something that is meaningful to oneself helps one's comprehension of mathematical and scientific concepts. He argued that children learn these concepts by manipulating and building physical models (Ackermann 2001; Papert 1980).

Based on the constructivist approach, researchers design tangible interfaces that support embodied learning in which an individual visitor can think through and create meaning around abstract concepts (Bakker et al. 2012; Marshall 2007). The physicality of the interface has been supportive of exploratory, expressive interactions (Marshall 2007) and gestural interactions are used as embodied metaphors (Bakker et al. 2012). Marshall (2007) explains that physical form that embodies abstract concepts may assist the interactor in internalizing or externalizing abstract concepts through interacting with physical models.

Researchers have also identified the spatial aspect of tangible and interactive interfaces to support collaboration between multiple people in a museum space (Hornecker & Burr 2006; Horn et al. 2009). Tangible interfaces provide platforms for collaborative activities in which visitors can learn through emergent dialogue (Antle et al. 2011). Perry (2012) argues for designing interactive experiences that facilitate visitors' active participation and interpretive processes, rather than focusing on transmitting knowledge. She states:

> Rather than lecturing and monopolising the language space . . . what if [museums] gave visitors the tools they need to engage in meaningful conversations with their companions? In other words, what if exhibits (including labels, but other components as well) were specifically designed to contribute to visitors' conversations rather than interrupting them?" (Perry 2012: 29)

In this context, Horn et al. (2012) suggest a hybrid approach that offers flexibility to interactors to choose the most appropriate interaction style.

With all this in mind, the *cognitive impact* of tangible and embodied interaction can be beneficial when it supports visitors' interpretive process, which includes conversations and interpretation of the experience. What needs to be investigated more is how the constructive approach can be woven into the overall museum narrative to cultivate meaning-making practices. However, with its focus on cognitive support, the constructivist approach, dominantly applied to STEM (Science, Technology, Engineering, Mathematics) learning, may not apply to cultural historical museums, which focus on revisiting cultural practices and memory. Rather than teaching abstract concepts, a cultural history museum strives to invite visitors into a dialogue about heritage and history.

2.1.2 Sensory Engagement

Tangible interaction or touch with artifacts has been highlighted as a way to forge a personal connection visitors can make with an object so they can interpret the meaning of the artifact through their senses (Dudley 2013). Dudley argues that visitors understand objects through engaging in sensory experiences, in addition to the level of information

ascribed to those objects. For Dudley, touch can unlock the meaning of an object and provide visitors with a lived experience. Dudley references Classen and Howes (2006) and suggests that touch or sensory modality brings intimacy by connecting the visitor to the object's creator through sensory and social biographies: "By touching a collected object, the hand of a visitor also encounters the traces of the hand of the object's creator and former owners. One seems to feel what others have felt and bodies seem to be linked to bodies through the medium of materiality of the object they have shared" (2006: 202).

Researchers identify this personal connection with artifacts as a way of evoking meaning that is tied to one's identity. Paris and Mercer (2002) propose that visitors make meaning through developing their own identity, which they call a '*transaction.'* From this view, engagement with artifacts in museums is a personal transaction; it motivates visitors to think of their own identities and those of group members. That is, the meaning of an object is relevant to one's personal identity rather than to the content of an exhibition. Latham (2013) claims that through transaction with an object, an individual elicits the meaning of the object in reaction to his or her own experience, which in turn creates an active dialog with the object. Based on various researchers investigating the value of physical engagement with artifacts, we can summarize that touch or physical contact forges a personal connection between artifact and visitors, creating an active dialogue dependent on the visitor's identity that reconfigures the meaning of the artifact.

Museums have collections for the blind that can be touched (Levent & Pascual-Leone 2014), creating a more inclusive exhibit and expanding the sensory channel. However, such simple expansion seems limited, and shortchanges the potential of sensory engagement in meaning-making. Handling an object in a narrative context can transform

a perceptual space into an inhabited space of a historic cite (Ciolfi 2004). Therefore, I argue that integrating physical and sensory experience into visitors' meaning-making requires narrative-framing.

While the literature suggests multiple benefits of hands-on, and multi-sensory, embodied interaction in museums, the design and application of such knowledge within ethnographical and cultural museums has been underexplored and lacking in design guidelines. Thus, I suggest using embodied narrative as a design approach for placing artifacts in their cultural context and engaging visitors in the dialogue of interpretation in ethnographic and cultural history museums.

2.1.3 Narrative Imagination

Museums engage narrative to present a story that supports the particular interests and goals of an exhibit, and also to open up dialogue to visitors for interpretation. Narrative can be a useful framework for describing how museum visitors arrive at meaning. Narrative experience in a museum can "knit together multiple artifacts into a coherent visiting experience" (Bannon et al. 2005: 62). Also, a narrative approach allows visitors to create their own storylines and construct their own meanings. Roberts (2014) argues that museum displays should pave the way for interpretation by engaging visitors in finding meanings in artifacts that are personally significant to them. As opposed to a one-directional epistemic discourse, researchers are suggesting a participatory model of narrative with a circular epistemology that promotes visitors' reflection and response. In this inclusive participatory model, visitors are no longer spectators who passively receive information, but actors who actively investigate and interpret the exhibit's meaning.

Tangible and embodied interaction is a way of cultivating one's mind for meaning-making through narrative imagination. Bedford (2014) states the importance of a somatic experience as a way to support narrative imagination, which is essential for cultivating an active mind for meaning-making. She suggests in her book that successful embodied experience encourages visitors to be "sufficiently engaged [so that] they can become an actor in the story-world and move themselves through the story, shifting from conscious to unconscious engagement depending on their own narrativization of self " (Bedford 2014: 76). For Bedford, bodily experience can support the liminal experience to imagine visitors at a museum as experiencing the story. In addition, Bedford (2014: 68) has suggested somatic experience as a way to have a bodily experience of narrative imagination: "Somatic understanding is about understanding experience in a physical, pre-linguistic way. Information comes through the senses as our physical bodies interact with the environment." MacLeod et al. (2012: xxi) also share that storytelling in museums is represented through "a fully embodied experience of objects and media in three-dimensional space," which is created through a narrative sequence.

In this somatic experience, narrative offers ways for visitors to take their own personal perspective to interpret the meaning of their sensory experiences. As museums have changed from using knowledge transmission methods to interpretive methods (Roberts 2014), embodied interactive narrative with an artifact can be used as an effective method to engage in and learn within the cultural context of various artifacts.

2.1.4 Conclusion: Tangible and Embodied Interaction in Museums

Tangible and embodied interaction can bring cognitive impact to support visitors' interpretive processes and sensory-motor engagement and invite them into a dialogue about heritage and history through making a personal connection with the objects with which they interact. Tangible and embodied interaction that promotes visitors' narrative imagination can engage visitors to become participants within the story provided through the museum and guide visitors' coherent experience for meaning-making.

2.2 Interactive Narrative Experience

In this section, I review interactive narrative experiences as discussed by Murray (dramatic; 2017) and Ryan (cognitive; 2015; 2006) to give readers an understanding of how an interactive narrative engages the interactor by assigning him or her a narrative role and providing immersion. Reflecting on embodiment and its relevance to interactive narrative experience will support revisiting the interactive narrative framework to consider the physical space of the interactor beyond the virtual domain.

Digital media, through unique affordances of interactivity, have fostered dramatic changes in how narratives are introduced to readers. Rather than having a singular plot, an interactive narrative has a multi-sequential structure. Aarseth (1997) examines various digital texts ranging from games to hypertext fiction and describes their multi-sequential, open and dynamic structures through the term "ergodic literature." This openness of plot offers a narrative structure that can be disintegrated and re-constructed by the interactor's engagement. Crawford (2012) identifies interactivity as a dialogue or conversation, in which each participant listens, thinks, and expresses. Comparing the various uses of the concept of interactivity, Murray (2017) calls interactivity "a loose term" that is often

confused with potential action and proposes instead using the term "agency" to describe the pleasure of being motivated and empowered to take action.

2.2.1 Murray's Dramatic Approach to Interactive Narrative

Examining the concepts of "Agency" and "Immersion," which Murray (2017) proposes as contributing to the aesthetics of digital media, can help understand how interactive narrative provides engagement with narrative. Agency refers to the pleasure of participating in an interactive system through properly structured expectations, interaction, and feedback. Immersion describes the pleasure of being contained within an experience without interruption. In Murray's dramatic approach to narrative, agency and immersion reinforce each other: being immersed motivates one to practice agency, and the ability to make changes to a story with agency supports one' immersion.

2.2.1.1 Agency

The dramatic model of the narrative, proposed by Laurel (2013) and Murray (2017), focuses on *the participatory role* that the interactor plays while engaging in an interactive narrative. Laurel (2013) compares participating in an interactive narrative experience to taking on a role with agency in a stage play. Using an analogy between improvisation and interactions with computers, Laurel (2013) explains that interactors become actors in order to perform on stage and interact with their environment. In conventional media, readers remain passive, with little-to-no agency; in contrast, in interactive media, the interactor has agency, or the power to perform a role as a character or a narrator in the story. Rather than engaging in passive viewing as is done in conventional media,

interactors in interactive media engage with stories by actively intervening and commenting on the story.

The dramatic approach by Murray (2017) involves the pleasure of participating in a story through one's agency. Murray (2017; 2011) proposes designing an interactive system (e.g., websites, games, or other systems) that assigns agency to the interactor, who actively participates to make changes to the system. According to Murray (2017), "Agency is the satisfying power to take meaningful action and see the results of our decisions and choices" (Murray 2017: 126). She states that agency is created by one's participation in a procedural system (e.g., computers) that scripts the interactors' expectations of and maps their behaviors with the system's responses. The interactive system is programmed to properly sense and respond to the interactor's actions. It also provides cues that motivate the interactor to take intended actions. For example, although interactors may be offered a path to choose, they would not be considered to have agency if they could not explain how their choice is motivated by the the unfolding story, or if the system did not respond in the way they expected.

Within an interactive narrative experience, Murray (2017) compares the process of creating agency as "structuring participation" by giving roles to the interactor to act, so that interactors are prepared to act out their fictional roles beyond their real world identities. Interactive narratives can have several forms that provide agency, such as navigation in a spatial environment, an adventure story in a maze, or constructive interaction to combine or manipulate narrative. Murray (2017) further explains the term "dramatic agency," which makes use of compelling story elements to script the interactors' narrative expectations and map them to yield a proper narrative outcome.

While the term "agency" can be broadened by being applied to designing interactions with a narrative environment or any kinds of interactive systems, Murray's term "dramatic agency" focuses on how the interactor's choice integrated with narrative outcome results in the interactor's active engagement with the fictional world. Murray gives an example of the story game *Gone Home (2013)* to illustrate dramatic agency, in which the desire to find out what happened to the missing sister provides motivation for interactors to examine objects within the eerie house. As interactors piece together the story by finding clues from objects, they experience dramatic agency.

Investigating the concept of agency informs the design method and goal for interactive narrative systems. Agency does not only mean that one can choose the ending of a story, but also means being invested in that choice. Tanenbaum and Tanenbaum (2009) argue that the concept of agency has been misunderstood by game designers as giving choice results in a design that offers various choices, but not the pleasure of being invested in the choice. He suggests that since choice does not enhance the believability of a character, various choices disrupt taking part in a narrative. In an effort to allow meaning-making by reading and believing in an interactive narrative, the author suggests giving a few choices of a character's actions that are consistent with the overarching narrative design and goal, so that the interactor may commit to the story's intended meaning. Here, agency does not come from making a choice, but instead, from the process through which interactors invest in meaning (Tanenbaum & Tanenbaum 2009). What we can learn from Tanenbaum's research is that agency is to be involved cognitively to take part in the story.

Suggested by narrative scholar, Bal (2009), a narrative can have three different roles: that of a *narrator, actor,* or a *focalizer*. What we can learn from Murray (2017) and Tannenbaum's (2009) investigation of the concept of "agency" is that interaction involves performing these roles, such as narrator, actor, or focalizer in a story through speaking, acting, and seeing.

Considering these three roles within an interactive narrative, the interactor as a *narrator* constructs stories and describes them as he or she makes interpretations. While the interactive system gives feedback, the interactor can play the role of omniscient narrator to recount the events in the story.

The interactor may play a role as the actor whose changes in state constitute events. While conventional media calls upon interactors to read stories about actors, interactivity allows them to play roles as actors and experience the story. As an *actor*, the interactor plays the role of a protagonist and actively takes part in the events to bring about change.

The interactor can also be a *focalizer* who observes events without having an active presence. The interactor may take the perspective of a character in the story or that of an anonymous agent who is outside the story. As a focalizer, the interactor follows characters and moves about the world through their perspectives. For example, instead of listening to a narrator's voice communicating suspense, the interactor makes meaning from hearing a creepy background noise that indicates suspense.

Murray's concept of "agency" refers to how the interactive system is designed to react in response to the interactor's choice, and also to how the interactor's role and expectations of that role are scripted. In this sense, an interactive narrative with agency should be

responsive on a systematic level. It should also provide a clear narrative role and motivate interactors to take part in the story on a design level.

2.2.1.2 Immersion

Murray (2017) adds that being involved with narrative with agency enhances the immersive experience where interactors suspend their disbelief of the fictional world. A trick to structuring interactivity to produce immersion is what she (2017) refers to as a "threshold experience," which exists between the virtual world and the real world, within our imaginations. Referencing the term "transitional experience" by Winnicott (1971), she describes narrative as creating a liminal space between reality and the fictional world. Through the threshold experience, we can imagine and interact within fictional stories as if we were actual characters in the fictional world. Furthermore, real world physical interaction can further reinforce immersion/imagination for interactors to take action in the storyworld. Murray (2017) defines a "threshold object" as a physical object that exists in both the real world and the storyworld as an imaginary device. A threshold object, which is a reminder of the boundaries, can direct connection to and out of the immersive world.

Murray (2017) discusses how a physical interaction as a threshold experience can provide a sense of agency through the methods by which it evokes the narrative role of interactors and maps their actions to a proper narrative outcome. For example, holding a six-foot shooter gun as a game interface can provide agency to the interactor by reminding one of one's role and narrative expectations. She suggests:

> Ideally, every object in a digital narrative, no matter how sophisticated the story, should offer the interactor as clear a sense of agency and as direct a connection to the immersive world as I felt in the arcade holding a six-shooter-shaped laser gun and blasting away at the outlaws in *MadDog McCree.* (Murray 2017: 146)

Murray uses the term "diegetic" to describe how an object exists in both the physical- and virtual worlds to help interactors engage with the story (Murray 2017). The concept of "diegetic" is also used in film. Film utilizes the term to distinguish background sounds that cannot be heard by characters in the movie but are added to enhance the emotional impact on the interactor and sounds that actually appear in the movie (Bordwell & Thompson 2016). For example, a theme song played in the background of a movie would be non-diegetic, since the actors within the story cannot hear it. In contrast, the sound of a gun blast as part of the story would be diegetic, since the actors within the story can hear it.

In this sense, interfaces such as game controllers, which map onto real-world objects or real-world actions with narrative impact, may assist with not only immersion, but also agency through the means by which they elicit a narrative role from the interactor. With the growing number of immersive experiences via emerging technology such as virtual reality (VR), augmented reality (AR), and tangible interaction, the concept of a threshold object can serve as an important design principle that fosters an enticing experience with the aesthetic pleasure of immersion and agency. Murray's concept of a threshold experience teaches us that interactive interfaces that provide an immersive experience not only give one the ability to play a role and cognitively invest in a story, but also help one

imagine the details of the fictional world to perform one's narrative role as a narrator, actor, or focalizer.

2.2.2 Ryan's Cognitive Approach to Interactive Narrative

Ryan's (2015; 2006) cognitive approach to interactive narrative describes narrative comprehension through immersion and interactivity. For Ryan, immersion takes place when the interactor is transported to and enters the virtual world; interactivity takes place when the interactor remains outside the medium of the story and restructures the story, thus disrupting immersion. In order to describe interaction as one's relationship with an avatar, Ryan furthermore provides a framework.

2.2.2.1 Immersion

Ryan (2015; 2006) applies what I call "the cognitive approach" to interactive narrative with a storyworld model to explain the mental process of interactivity and immersion. In order to discuss interactivity, she examines immersion in the mode of reading and applies it to describe interactive experience. Ryan (2015) has referred to cognitive narrative scholar Herman's (2004) description of the process of narrative comprehension by transporting oneself to the space and time of the storyworld as a process of immersion. Herman describes storyworlds as "mental models of the situations and events being recounted-of who did what to and with whom, when, where, why, and in what manner" (Herman 2004: 73). A storyworld model describes narrative comprehension as the interactor's construction of a mental image of a storyworld by taking up residence in the fictional world.

Adapting Herman's storyworld model, Ryan (2015) describes the aesthetic pleasure of immersion in virtual reality as transporting oneself to the storyworld and imaginatively reconstructing the imagined world. She claims that readers transport themselves to the storyworld and relate to an avatar through "textual re-centering." A rich mental simulation is "a strong form of the experience, by which 'thinking of' means imagining not only an object, but the world that surrounds it, and imagining ourselves contained in this world, in the presence of this object" (Ryan 2015). It involves a process through which "the reader identifies with the agent rather than contemplating the moving body from a distant perspective" (Ryan 2015: 82). In an interactive system, the interactor relates to the virtual avatar to experience the storyworld. One would eagerly shift one's perspective as a character and imagine actually exploring the storyworld as that character does.

In addition to transporting oneself into the storyworld, narrative comprehension requires the interactor to make sense of the storyworld as the completion of a system. To fill the gaps, the reader reconstructs a complete storyworld through interpretation. This construction of the storyworld is based on the interactor's own experience and imagination. In this sense, a storyworld is an ecology for narrative interpretation in which a reader, in order to make sense of the fictional world, must not only focus on what happened, but also imagine the context involved with the events in the storyworld. Ryan (2015) describes how readers fill in the gap of the undescribed storyworld through imagination based on their background experience and cultural knowledge. In her book, *Storyworlds across Media: Toward a Media-Conscious Narratology,* Ryan, (2014) describes the storyworld as "more than a static container for the objects mentioned in a

story; it is a dynamic model of evolving situations, and its representation in the recipient's mind is a simulation of the changes that are caused by the events of the plot" (Ryan 2014: 33). In this context, the interactive experience is composed of oneself mentally imagining the experience of a virtual avatar and interpreting and making sense of such an experience.

In Ryan's (2015) understanding, immersion in an interactive system not only comes from the ability to imagine oneself transported to the virtual world, but also from the ability to fully imagine and interpret any details of the virtual world. Thus, Ryan's notion of immersion should be understood as an active cognitive state describing how the interactor can grasp the details and meaning of the events in the virtual world through his/her imagination.

2.2.2.2 Interactivity

Ryan's cognitive approach to interactive narrative describes interactivity as a writerly mode where an interactor constructs the virtual world by manipulating a medium (e.g., text, computer screen, virtual space, or any other). For Ryan (2015), interactivity means exploiting the medium while immersion involves looking through the signs to the referenced world; but interactivity, by nature, results in dysfunctionality by providing a disintegrated, incomplete storyworld to the reader and asking the reader to rewrite the text. Ryan draws a comparison between immersion and a "readerly" text and between interactivity and a "writerly" text. This writing mode for Ryan seems to be self-reflective, directing attention to the text, which disrupts immersion. For Ryan, as the interactivity of the game system is detrimental to immersion in the virtual world environment, the only

way these two concepts can be compatible is by providing interactivity that can contribute to the reading mode through a transparent interaction that does not focus on the medium of a text, but instead on the storyworld.

Ryan adapts Murray's dramatic approach to narrative to describe immersed interaction as being members of a dramatic performance in the virtual world. However, her notion of interaction is limited to only transparent experience, where the interaction aligns with the narrative events in the fictional world. In this sense, digital media can offer the experience of interactivity while being immersed by tightly coupled interactivity with a narrative whose textual aspects align with those of reality. Ryan states that interactivity can reinforce immersion by allowing bodily projection into the virtual world. Although she claims that immersion can be reinforced through interactivity by situating one's body in the virtual world to act upon, she asserts that interactivity can cause the storyworld to disintegrate, disrupting immersion.

Ryan, who considers narrative as a mental phenomenon, seems to offer a limited understanding of interactivity. However, considering the development of digital media that offer various types of physical interactive experiences with the narrative beyond mere imagination, Ryan's notion of "narrative" may need to be expanded. Identifying narrative as not merely a mental construct but also a physical experience would also expand Ryan's description of interactivity.

2.2.2.3 Many Forms of Interactivity

To aggregate various forms of interactive narrative, Ryan (2006) identifies interactive experience as the interactor's relationship with an avatar, or a character in the story. She

examines interactivity in terms of engagement between the interactor and the story through involvement with one of the major narrative components: character and plot. Her framework consists of two binary pairs—*internal vs. external* and *ontological vs. exploratory* that are combined to offer four different types of interactive narrative experience. This framework models interaction as dramatic performance in the story and describes engagement with the storyworld as determined by narrative perspective and narrative impact. The internal and external pair relates to the narrative perspective of the interactor, and the ontological and exploratory pair relates to the impact of the interactor on the story.

2.2.2.4 Internal vs. External

Ryan makes a distinction between internal and external interactivity based on various types of interactor participation, i.e., whether the interactor is within the storyworld or outside of it. This distinction determines the interactor's point of view and the level of narrative engagement. If interactors are internal, they experience stories inside the time and space of the storyworld through an avatar. From her internal narrative position, the interactor plays the role of a character and forms a relationship with that character to gain firsthand experience and narrate/tell/ focalize the story. Ryan (2006 2006: 124-25) describes the pleasure of internal interactivity as simulating and transporting oneself to the virtual world: "We simulate mentally the inner life of these characters, we transport ourselves in imagination into their mind, but we remain at the same time conscious of being external witnesses." Although Ryan does not distinguish between an internal narrative position and immersion, what she describes as internal narrative position is similar to the process of immersion.

Unlike in the internal narrative position, the interactor does not identify with a character or an avatar in the story. In the external mode of interactivity, users examine stories outside of the storyworld from a different time and space, where they may be navigating a database or playing the role of God. Although Ryan (2006) does not explicitly state it, the interactor in her framework may also be taking a first-person perspective, but simply revisiting the site and listening to the stories through his or her imagination or listening from the position of the omnipresent narrator after the event has concluded. In this mode, compared to the internal mode, the interactor may play a more objective, observational role. The external narrative position seems to be the opposing state of immersion since interactors do not transport themselves into the storyworld.

2.2.2.5 Ontological vs. Exploratory

Ryan (2006) explains a type of narrative engagement as "ontological" or "exploratory," depending on whether the interactor modifies the raw materials of a story by intervening on events, or navigates and reorganizes a story without making changes to any events. In ontological engagement, one's actions or decisions lead to forking paths that in turn lead to various stories in the ontological mode. The interactor may play the role of an actor in a story, or that of an omniscient narrator who creates the story.

In an exploratory mode, the interactor navigates the story without changing it or leaving a trail. While narrative events may remain the same, the way they are told may change, depending on the interactor's navigational path. If interactors are internal to the story, they observe and discover the storyworld events without impacting them, and their success or failure does not alter the outcome of the story, even though it may limit their

access to the story. If external to the story, the interactor plays the role of a narrator or that of a focalizer. Ryan analogizes this type of external-exploratory interactivity to assembling a jigsaw puzzle in a different order: The narrative leads to the same ending regardless of the order of interaction.

2.2.2.6 Ryan's Cross-Classification

Ryan (2006) describes various interactive stories that can be told through combinations of design choices and modes of interactivity. Her framework can be informative when one designs and maps various types of interactive narrative experiences that come from particular combinations of narrative engagement. For example, external and ontological engagement is provided through simulation games; and internal and exploratory engagement is provided through exploratory environments.

2.2.3 Conclusion: Interactive Narrative Experience

Reviewing Ryan's (2015; 2006) cognitive approach and Murray's (2017) dramatic approach to interactive narrative informs this study. Their approaches allow me to regard involvement with the story as an active state of taking part in a narrative and as mentally and physically investing and getting involved in the fictional world. Entering the storyworld and getting mentally involved in the story can increase the interactor's ability to make narrative interpretations.

Ryan's cognitive approach describes the interactor's cognitive involvement with experience, thereby interpreting the virtual world. However, her approach diminishes the experiential aspect of interactivity by identifying the interactive experience as

transportation into a virtual world. While Ryan's framework provides a useful model to understand and categorize various types of interactive experience, it seems to be limited, as it does not include the physical domain.

In contrast to Ryan's view that interaction disrupts immersion, which is a mental phenomenon, Murray (2017) believes that narrative imagination is also triggered by real-world interaction as a threshold experience. She embraces physical experience and objects as creating an imaginative relationship with the virtual world. Murray's view on threshold experience enables me to examine physical experience as a process of making sense of the storyworld. However, Murray does not provide a strong explanation for the relationship between objects and our imaginations. A useful model for understanding such a relationship is the concept of embodiment, which I examine in the next section. Examining embodiment can help us understand how tangible and embodied interaction involves the interactor and triggers imagination.

Museum exhibits involve physical settings, which make it necessary to identify tangible experience as its design element. In museum exhibits such as full-sized reenactments, a space is transformed into an immersive world in which an interactor can become a member who navigates the scene. Touch screens with highly informative interfaces encourage the interactor to examine myriad scenes based on conceptual thinking. Since museum exhibits create a physical, realized narrative environment, we need to examine how embodiment in a scene becomes a component for interactive narrative experiences. Understanding this incidence can help museum installations empower visitors to take part in meaning-making, augment their imagination, and expand their depth of knowledge.

2.3 Concepts of Embodiment

In the third wave of Human Computer Interaction (HCI), HCI researchers focused on the concept of embodiment to learn about the situated and contextual aspects of interaction with computer systems (Harrison et al. 2007). The concept has influenced interactive design not only from the perspective of physical engagement between a user and computational resources, but also from a socio-cultural standpoint that includes understanding the construction of the situation. For example, the design of an information kiosk involves not only the aesthetic aspect of the kiosk itself, but also its involvement in the information ecology within society. Here, meaning, constructed through embodied interaction, is not fixed, but rather, contingent upon the situated context.

Harrison et al. (2007) asserted that the third wave of HCI provides a situated perspective toward the construction of meaning. It is "irreducibly connected to the view-points, interactions, histories, and local resources available to those making sense of the interface and … beyond the reach of formalization" (Harrison et al. 2007: 7). The meaning that is derived from the use of an information kiosk is not defined by the way the kiosk was purposefully designed for display; rather, it is defined by the different ways in which it is used by visitors within their own cultures and circumstances. People may collaborate to interpret information through the kiosk by sharing thoughts around the given information, or the kiosk may function as a resting area where people can sit down and relax. In other words, the meaning, which is the purpose and function of the kiosk, is contingent upon the context in which the kiosk is placed and how visitors use it.

Studies of embodiment have transformed our notion of how human actors discover meaning from the world around them: not from the inside out, but from the outside in, or in a cohesive feedback loop. The broad scope of embodiment necessitates a clear definition. In his book, *Where the Action Is,* Dourish (2004) defines embodiment as a physical property of the world, or "possessing and acting through a physical manifestation in the world… occur[ing] in real time and real space" (2004: 100-101). Dourish claims that everything that we interact with and are able to act upon is embodied, and includes interfaces in the physical world as well as interactions in the virtual world. For example, in museums, which are the focus of my dissertation, motion-sensing technology, which enables an interactor to move about the virtual environment with one's finger, is also an embodied phenomenon even though the interface of motion sensing is not physical because the interactor has a participatory status in real time.

Based on the physical properties of the physical situatedness of embodied action, Dourish (2004: 126) examines how we make meaning from our interactions, asserting that "Embodiment is the property of our engagement with the world that allows us to make it meaningful." Influenced by social and cultural approaches to embodiment, he claims that meaning is contingent in an interactional context rather than being predefined. This idea aligns with social anthropologist Suchmann's (1987) view of human-computer interaction that emphasizes the situatedness of human action. From this perspective, embodied interaction takes place in socio-cultural situations. While Dourish takes a general stance toward embodiment, Clark (1998) focuses on how we cognitively utilize the environment for reasoning and a as problem-solving tool. For Clark, the combination of these tools with our bodies extends our cognition.

Drawing on Dourish (2004), Suchmann (1987), and Clark (1998), I focus on the cognitive and socio-cultural aspects of embodiment and define it as follows: (1) Embodied interaction involves the incorporation of physical objects into one's cognition, and (2) such interaction is situated within a socio-cultural context that shapes the meaning of one's actions. Operationalizing this definition, I examine three approaches to embodied interaction that can provide explanations for how objects support narrative experience and imagination. These approaches, *external cognition, sensory motor engagement,* and *situated action*, describe the relationship between objects and our meaning-making process, or our involvement in our imagination.

2.3.1 External Cognition

External cognition (Clark, 1998) involves offloading our cognitive tasks to our environment in order to support mental processing. External cognition relates to the idea of distributed cognition as the way we understand how to perform tasks through distributing cognition and knowledge not only in individuals, but also objects in the environment and their relations to each other (Hutchins 1996). Similarly, for Clark (1998), our minds undergo cognitive processes through interplay among the brain, the body, and the environment. For example, we refer to our phones' applications that provide phone numbers that we are unable to remember or maps that navigate us to places that we are unable to find without assistance. Not only do such means of guidance assist with memory, but we can also lean on them to perform cognitive tasks. For example, with a compass and a pencil, we can draw a perfect circle, or with the help of parents, infants can take their first steps. In these cases, physical objects function as scaffolding that guides humans through interaction and cognitive processes.

With regard to narrative experience in museums, I see objects as containing narrative memory that functions as external scaffolding to support the reconstruction of a story by jogging one's memory. Holding grandmother's pearl necklace may evoke memories related to her through the way we assign meaning to such antiques with the life of the owner. Turkle (2011) uses the term "evocative objects" to illustrate how we consider objects closely related to our lives and memories as tools that evoke past memories. In these cases, the link between objects and our memory appear to rely on personal meaning and experiences related to such objects, and these meanings are triggered in our imagination upon encountering such objects. Objects may not only trigger stories of their owners, but also of the related place and time. We keep souvenirs from travels in order to remember the place and time of the visit. Holding a seashell would provoke memories of a beach during a summer vacation.

Objects that trigger imaginations may furthermore promote organizing stories depending on time, location, or with corresponding narrative roles. We may use a map as an external scaffold to organize and tell stories about the history of the Second World War since geography assists with describing the dynamics of the war. Our fingers tracing the map assist imagining the events that occurred at a place and time represented on the map. When children tell stories using toys and a doll house, the toys assist in creating and telling stories that relate to certain roles and places. As seen from these examples, narrative imaginations that are triggered may come from personal experience, or the story of the owner or from the space and time related to such objects. Interacting with objects supports imagining stories that relate to such objects in a way that ties to the context of time, place, location, or people.

In various ways, external cognition implies that tangible objects can provide guidance toward narrative imaginations that are contextual. The value of external cognition lies in our ability to use physical objects or the environment as a tool to reason with, beyond using them as simply data storage or an extension of our abilities. Bodily interaction with these objects offers more than simply transferring information. It encourages us to use them in recalling memories and organizing and expanding our thoughts so that they encompass a broader dialogue that integrates investigation, personal experience, and motivation.

2.3.2 Sensory-Motor Engagement

Sensory-motor engagement is an ecological approach proposed by Gibson (2014) and extended by Valera, Thomson, and Rosch (1991, cited in Shapiro 2010) that acknowledges that rather than simply experiencing a world filled with fixed meaning, individuals perceive their own meaning from the world, depending on their bodily and cultural context. That is, it describes perception as determined by individuals' motivations, motor capabilities, and movements. It incorporates individuals' differences into a dialogue of sense-making. Gibson (2014) considers an interactor's mind and body and the environment that work in tandem as a single system; for him, cognition is not merely a product of the mind, but something influenced by the body with sensory-motor capabilities within a situation. The actions of interactors emerge as part of the environment in which their performance transforms the environment, allowing perception to take place in a coherent feedback loop. Drawing on VTR, Shapiro describes such individuals as "Cognizers [who] make their world, in some sense, as a result of activities that reflect the idiosyncrasies of their bodies and perceptual systems" (Shapiro 2010:

56). In other words, individuals shape their worldview through interaction, which is contingent upon their backgrounds, capacities, and motivations in the world. From the sensory-motor approach to embodiment, a river would be perceived to be crossable or not, depending on the movement and location of the perceiver. This perception is individual and dependent on context: two people with different bodily capacities will perceive and act upon the world differently.

In this sense, interacting with objects or the embodied environment through their sensory-motor capabilities provides cues for motivating individuals to find meaning. For example, a rusty sword, from the way it looks or smells, may invoke one to touch it, and through touching, one may imagine its history; others may focus on the heavy weight of the sword, which may remind them of heavy training and courage. We can learn from the sensory-motor approach that the world provides resources that are not representations of knowledge, but are sought and interpreted through our capacities, imaginations, and sensory engagement in an effort to shape knowledge. This approach focuses on how the embeddedness of the human interactor within an environment motivates and guides one toward sense-making.

2.3.3 Situated Action

The situated action approach informs us that the decisions people make are situated in their socio-cultural context and people incorporate tools within their own needs and purposes. Suchman (1987), who focuses on the socio-cultural context of embodied interaction, identifies one's actions as a way to act on and make decisions based on resources within one's situation. She provides an example of Trukese navigators who

react to their circumstances and conditions to find their path rather than relying on and operating according to a plan. Trukese navigators are only able to make their way along a path when they are in the woods (i.e., a situation); they would not be able to navigate the real path by simply viewing a map. Through the example of Trukese navigation, Suchman illustrates that decisions and actions are made not from merely conceptual thinking, but from being part of a situated context. Suchman applies the idea of situated action to examine how people use their tools to adapt them in meaningful ways. She gives an example of people using computers based on their needs rather than fitting themselves to the original purpose of the computer. When people use computers, they do not simply operate the built-in functions of computers, but plan and perform a task by relying on their abilities augmented by the computer. In this way, situated action takes place via embodiment when an individual becomes part of the ecosystem or an aspect of the situation.

The situated approach to embodied interaction can teach us that embodied interaction with narratively rich objects within a narrative context situates the interactors within a narrative perspective to act upon and interpret the story about that object. The object becomes a tool that helps the interactor identify him/herself with the narrative role s/he is playing and to offer capacities within the story. This characterization and realization of a role helps interactors make sense of their actions based on particular points of view. In short, physical interaction with an interface evokes narrative roles within the narrated situation of a story. Interactors relate to and associate with roles through embodied interaction. However, objects do not simply carry meaning by themselves; rather, they gain meaning as people interact in the narrative and situational contexts of those objects.

Handling objects in a narrative context promotes interactors to become part of the narrative system, assume a narrative role, and interpret the story from a unique perspective tied to those roles. For example, holding a weapon while interacting with a fighter game reinforces the interactor to act rigorously, whereas viewing a weapon in a war museum may evoke an attitude of solemnity in the interactors toward the veterans. It is when people engage with an object in its own context that they relate to the object and assign meaning to it.

2.3.4 Conclusion: Tangible and Embodied Interaction and Narrative Experience

By reviewing the concept of embodiment and its relevance to interactive narrative experience, we learn that interacting with objects may evoke narrative meanings related to memory, sensory-motor experience, or narrative context. Examining the three approaches discussed above – *external cognition, sensory motor engagement,* and *situated action* – shows ways in which tangible and embodied interaction shapes engagement and meaning-making. These approaches tell us that objects do not contain a fixed, transparent meaning; for example, when referring to tools, scholars have identified them as being incorporated within an individual's cognition through their transparency (Merleau Ponty 1996). In contrast, we can learn from Dourish's (2004) concept of "(re)coupling" that takes place among many entities (i.e., objects, their functions, or people who interact with them) that people use objects and imbue those objects with meaning within the interaction context.

What I have examined through the use of objects in a narrative can be applied in a broader scope of tangible and embodied interaction such as gesturing in space or having

an haptic or virtual experience. Thus, tangible and embodied interaction is not just a tool for interacting with digital information; rather, it offers engagement to incorporate interactors so that they can participate in digital and physical narrative representations.

2.4 Summary

Chapter 2 examined the theoretical background and frameworks investigating the domain of museum interactions between visitors and artifacts, interactive narrative, and embodiment to provide background for this dissertation on tangible and embodied interaction design with narrative in ethnographic or historical museums. Examining tangible interaction in museums led to this study's focus on a narrative as a design approach to support imagination and embodied engagement. Investigating the *dramatic-* and *cognitive approaches* to narrative as described by interactive scholars (Murray 2017; Ryan 2015; 2006) helped identify what it means to engage visitors. The literature and theoretical frameworks reviewed in this chapter provide the background for analysis of related non-museum and museum projects that represent tangible and embodied narrative systems presented in the next chapter.

CHAPTER 3. RELATED NON-MUSEUM AND MUSEUM PROJECTS

This chapter examines how a tangible and embodied interactive system can be combined with narrative to provide various forms of narrative engagement to interactors of that system. It discusses related non-museum and museum projects in an effort to draw inspiration from how digital media, embodied interactions, and narratives work together to provide tangible and embodied narrative engagement. Examining these projects reveals the need to expand Ryan's framework for interactive narrative discussed at the end of this chapter, to include modes of tangible and embodied interaction.

3.1 Non-Museum and Museum Examples

A growing number of applications have integrated tangible interfaces (i.e., physical objects or bodily interactions with the environment) to promote interaction with narrative elements. Tangible interfaces couple tangible and embodied interactions with computational resources to physically engage the interactor with computational data through gestural and expressive interactions (Hornecker & Burr 2006). As part of an interactive narrative, a tangible interaction with narrative provides physicality as a way to engage interactors with parts of the story (Mazalek et al. 2002). Tangible and embodied interaction provides new types of narrative experience and expression by augmenting human activities, objects, and environments. For example, stories are provided through immersion and engaging physical interactions beyond text or screen interfaces in game- and virtual reality (VR) environments (Rheiner et al. 2014), Human Computer Interaction

(HCI) for storytelling and education (Gorbet et al. 1998), art installations (Snibbe 2008), and many other interactive systems.

Forms of tangible and embodied narratives that utilize physical action to engage interactors with a narrative are not completely new. In fact, similar examples can also be found in conventional interactions. Body movements and objects have served as narrative elements in various forms of art, learning, and entertainment. For example, puppets, toys, and dolls are ways in which children interact with stories during play. Numerous art and design installations have provided tangible narrative experiences. For example, theme parks realize the storied environment in a navigable space with full-size reenactments. In addition, games such as a treasure hunt or hide-and-go-seek use forms of storytelling and immerse interactors within a virtual story. These activities are augmented with digital media to provide enhanced play/narrative interaction through everyday objects and gestures within the everyday environment. With digital media, forms of storytelling and narrative have been realized in tangible and embodied forms to create a narrative environment with computational power.

3.2 Related Tangible and Embodied Narrative Projects

This section reviews a trajectory of relevant interactive narrative (non-museum and museum) works that have embraced tangible interaction technologies. Related digital systems that combine narrative and tangible interaction illustrate diverse ways to design and implement tangible and embodied narrative projects.

3.2.1 Non-Museum Examples of Tangible Narrative Systems

Examining non-museum projects informs the design of future museum installations that can offer diverse tangible and embodied interactive experiences that enable deeper engagement. Below, I examine non-museum projects such as digital works of art, toys, and educational products, as examples that illustrate tangible and embodied interaction with narrative, which can be emulated in museum projects.

3.2.1.1 Youtopia

Youtopia (Antle et al. 2013) is a multi-touch tabletop installation with tangible objects that teaches sustainability. It displays an interactive map that gives interactors the power to use a sequence of tangible stamps, menu blocks, and an information ring tool. The ring tool presents information about each stamp such as how much lumber is required to construct an apartment building or how many people it can house. The tabletop set-up allows space for multiple interactors to gather around it. Using the sequence of stamps, interactors collaboratively try to keep a balance among their resources to make sustainable decisions about human or natural resource development for land use. They thus build strategy and learn through their emergent dialogue, thereby playing the role of a Creator, creating a *virtual* utopia.

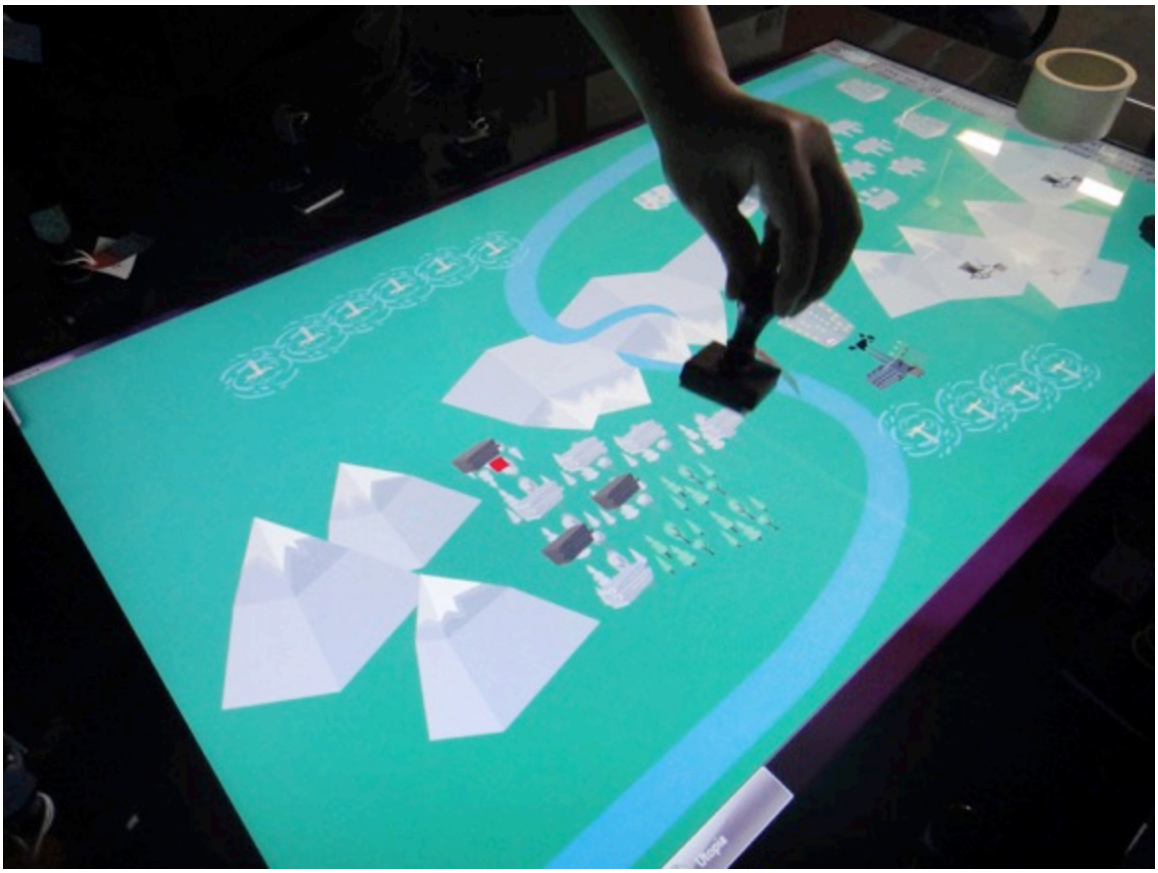

Figure 2. *Youtopia* game play (Antle et al. 2013)

3.2.1.2 Triangles

Triangles (Gorbet et al. 1998) is a storytelling application which consists of magnetic triangular pieces that can be stitched together in a variety of potential combinations, each creating different configurations of three stories (*Cinderella, Galapagos!*, and *The Digital Veil*). Different triangles show images representing different narrative elements such as characters, events, setting, and dialogue. The edges of the triangle pieces have magnetic connectors so that they can be snapped together or detached easily. The interactor thus manipulates the triangles, i.e., elements, thus assembling different configurations and hearing different parts of the story. For example, snapping together the image of

Cinderella's evil stepmother's face with the image of Cinderella's house would play the audio clip of Cinderella's step mother yelling at Cinderella. Whereas *Cinderella 2000* allows the interactor to only explore different parts of the same predefined story, *Galapagos!* allows the interactor to generate multiple stories.

Figure 3. The *Cinderella 2000 Triangles* (Gorbet et al. 1998)

3.2.1.3 Birdly

Birdly (Rheiner et al. 2014) is a VR installation with custom hardware that allows the interactor to lie on top of it and make bodily gestures of flapping one's arms or changing the angle of one's arms, while wearing VR goggles. Thus, the interactor experiences a full body interaction, which simulates flying. The project provides an immersive experience through simulated physical sensations of flying. The interactor becomes a virtual avian navigating a virtual landscape, for example, looking at the streets of San Francisco as if he or she were a bird. The installation utilizes environmental cues to

simulate flying: Moving one's body to change the direction one is flying and feeling the wind of one's speed through fans that are attached to the front of the installation. The installation supports the interactor physically to experience from inside the body of an unfamiliar species, not just imagined in the mind by looking at the screen. *Birdly* shows the potential of a companion physical interface to enhance the VR experience beyond an immersive screen.

Figure 4. *Birdly* (Rheiner et al. 2014)

3.2.1.4 Tangible Spatial Narratives

Tangible Spatial Narratives (Mazalek & Davenport 2003) consists of an interactive tabletop installation with tangible pawns on a tabletop that the interactors can select and

move around. The pawns represent characters in a story, and the tabletop shows a spatial arrangement of the narrative setting from a top-down view. The story is mapped within the spatio-temporal environment through the tangible pawns that represent different narrative points-of-view, allowing the interactor to examine various parts and layers of the story by placing and moving actual, physical pawns around the tabletop. Thereby, the interactor can examine different aspects and consequences surrounding one event.

Figure 5. ***Tangible Spatial Narratives*** **(Mazalek & Davenport 2003)**

3.2.1.5 Reading Glove

The installation *Reading Glove* (Tanenbaum et al. 2010) provides a tabletop with objects, which the interactor can hold wearing a glove with an Radio-Frequency Identification (RFID) sensor to listen to the story about an escaping spy. Touching tagged objects such as a clock or a compass on a table one by one, the interactor listens to and navigates parts of stories that relate to each object. The interaction resembles psychonomy, or remembering and being able to read stories through meaningful objects on the table. The objects function as a tangible interface on two levels: on a system level, they trigger recorded stories that will be told; and on an experiential level, they stir the imagination of the interactors who are transported to the time and place of the event. The objects guide navigation through segments of stories that provide hints about which direction one should take next, and also through the ways they drive the curiosity and imagination of the interactor. Although one is not present in the time and place of the story, when one is reminded of the scene through the shapes, textures, and smells of the objects, one can let one's imagination reach beyond the story that is told through the interactive system.

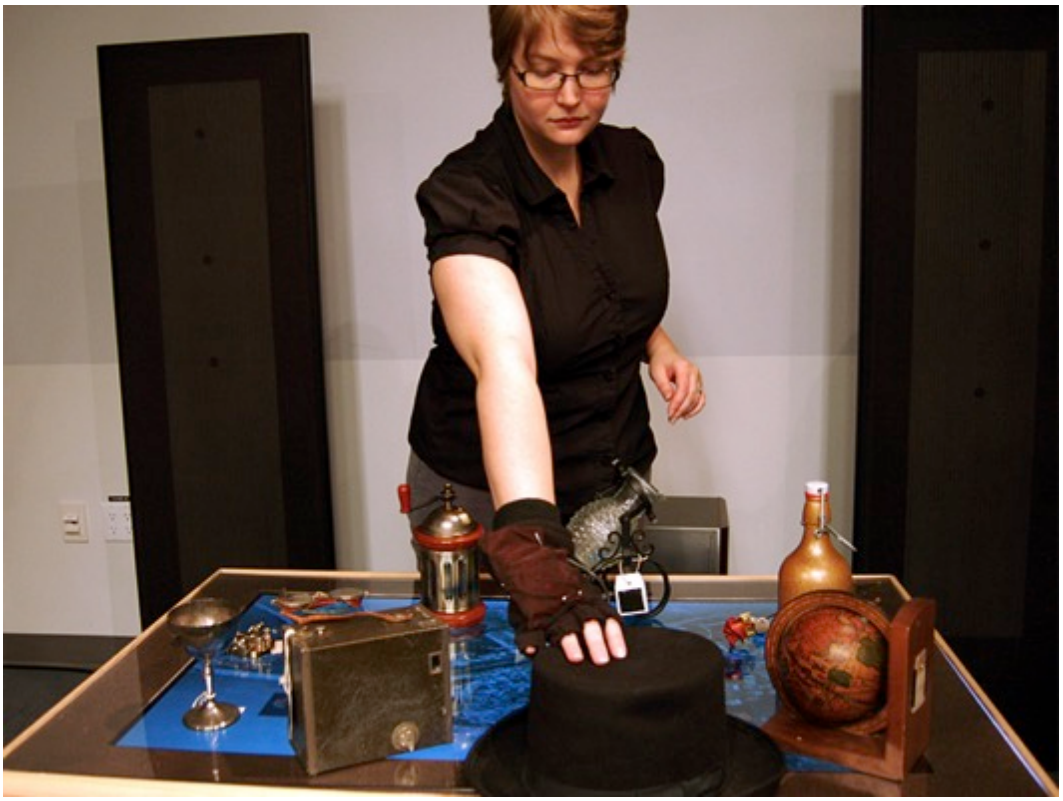

Figure 6. The *Reading Glove* (Tanenbaum et al. 2010)

3.2.1.6 TViews Table Role-Playing Game

The *TViews Table Role-Playing Game (TTRPG*) presents an interactive tabletop with tangible pawns for a role-playing game (Mazalek et al. 2008). Utilizing the tangible pawns and additional tools such as an option circle or a game master, interactors can set character attributes and skills, fight with each other, or read additional stories in the game. The three color-coded pawns correspond to each player. Moving the tangible playing pieces around the surface of the tabletop becomes the main way to navigate one's avatar within the virtual game spaces. The interaction in *TViews Table RPG* is similar to board games in terms of utilizing playing pieces to control one's game play, where the

technology for an interactive tabletop enables real time response for the game play such as changing character attributes or accessing additional stories.

Figure 7. Two players at the *TTRPG* game table (Mazalek et al. 2008)

3.2.1.7 Universal Threshold Object (UTO)

The *Universal Threshold Object (UTO*) (Chu et al. 2015) is a haptic controller for interacting with televised content as if one were the protagonist acting within the story. The *UTO* provides a tangible interface that is shaped ambiguously and can sense gestures such as grabbing or pointing. The interface functions as a flashlight or a rope that syncs with the story in the video so that the interactor can make a gesture through the interface as if he or she were immersed within the scene. When the tangible interface is synced with the video, the screen shows a close-up view of a hand holding a flashlight or a video, and the interface vibrates, reminding the interactor to make gestures in order to communicate with the interface.

While engaged with the *UTO*, the interactor plays the role of a betrayed wife, focalizing and experiencing the story from a first-person narrative perspective. By performing various actions with the interface that syncs with the video, the interactor is encouraged to play the role of a character in the story. The haptic interface translates what the actual character would feel and do through gestures and haptic feedback for one to act and perform as a character in the story. The interactor can steer the interface to view the corridor in the scene while feeling through his or her palm the imagined heartbeat of the character through vibrations of the interface. While watching the story of the betrayed wife looking for her husband and finding out that he is being strangled with a rope, the interactor can change the story. When the interface functions as a rope, the interactor can grab the interface to prevent the husband from dying, or s/he can let him die. By situating the interactor in a particular role and scripting the interactor's actions that have a narrative impact on the story, the project realizes what Murray (2017) refers to as "dramatic agency".

Figure 8. The *Universal Threshold Object* (Chu et al. 2015)

3.2.2 Summary: Related Non-Museum Projects

The non-museum examples I gave above illustrate valuable designs of tangible and embodied interaction with narrative, which museums can emulate (I discuss this recommendation in detail in Chapter 4). These examples show how digital systems can be incorporated with tangible and embodied interaction to provide a narrative environment that promotes engagement and supports one's interaction with and interpretation of a narrative.

3.2.3 Museum Examples of Tangible Narrative Systems

Tangible and embodied interaction can be a powerful tool to engage museum visitors. Examining related museum projects informs how museums implement existing digital

technology to enhance museum visitors' understanding of content. The selected museum projects in this chapter focus on educational goals, advantaging them over experimentation with digital technology and interactive modalities. Rather than developing diverse modalities and means of interaction, museums provide limited interactions to deliver content. Below, I examine examples of museum installations that utilize digital interfaces to offer engagement, to have an embodied experience with narrative and assist with meaning-making. As an inclusive term, "museum installation" consists of interdisciplinary qualities of museum exhibits, kiosks, public installations, and HCI projects in museums.

3.2.3.1 Lunch Counter Simulation, Center for Civil and Human Rights, Atlanta

The *Lunch Counter Simulation* is an installation inside the Center for Civil and Human Rights (2014) in Atlanta, Georgia. It represents a full-size re-enactment of the sit-in event that took place on February 1, 1960, at Woolworth's in Greensboro, North Carolina, when four African American college students sat down at a lunch counter to protest the exclusion of African-Americans from being served lunch. Consisting of a countertop and four barstools, the installation provides a poignant example of how an interface can situate the interactor within a narrative environment. The interaction is simple, where visitors put their hands on the countertop handprints to activate the system to play the sound. Visitors wear headphones to hear the voices of people yelling and smashing the table. Putting their hands on the countertop handprint triggers visitors' imagination as if they were really at the scene in the sit-in event. The bar stool vibrates as the table is being smashed, so that visitors can sense the brutality and tension of the scene almost as though they were present during the actual event. The rich sensory experience of being in an

event as a member of the scene motivates interactors to explore and discover issues further throughout the exhibit. This installation at the Center for Civil and Human Rights in Atlanta is a successful example of the use of interactive technology at a museum not only through situating visitors in the actual context of the event taking place at the lunch counter, but also through provoking interpretation.

Figure 9. *Lunch Counter Simulation* (Center for Civil and Human Rights 2014)

3.2.3.2 Virtual Reality at the British Museum

The 2015 Virtual Reality weekend event (Rae & Edwards 2016) at the British Museum in London provided VR goggles, which interactors could wear to inspect an artifact in 3D, such as a ring in a virtual scene of a Bronze Age site. However, it allows visitors to examine the scene without knowing what the artifact was used for or how to engage with it bodily or imaginatively, thus failing to support meaning-making. While the designers

state that the goal of the open-ended interaction was to raise curiosity around the artifact, the display does not require, or guide visitors toward carrying out, any tasks beyond browsing.

Figure 10. Virtual reality event at the British Museum (2015)

3.2.3.3 DeepTree

DeepTree (Florian et al. 2012), exhibited in the Harvard Museum of Natural History, is a multi-touch tabletop that enables visitors to visualize the history of the evolutionary relationship of millions of species 3.5 billion years ago. The fractal-based tree layout of the interface displays all life on earth. The screen interface consists of three components:

the main tree visualization, the scrolling image reel on the right with 200 species, and the action menu that helps the interactor to relate or find different species. Through the *DeepTree*, the interactor can swipe the surface of the screen with his or her fingers to zoom in and out or pan through the complexity of the tree of life. The data for an evolutionary tree can be extensive; yet the system is able to accommodate the big picture of the whole dataset, as well as allow for zoom-ins to focus on a specific species, or compare features among different species, as it enables one to fly through the vast tree of life of any species. The *DeepTree* visualization on an interactive tabletop encourages collaborative exploration and guided discovery to learn about evolution.

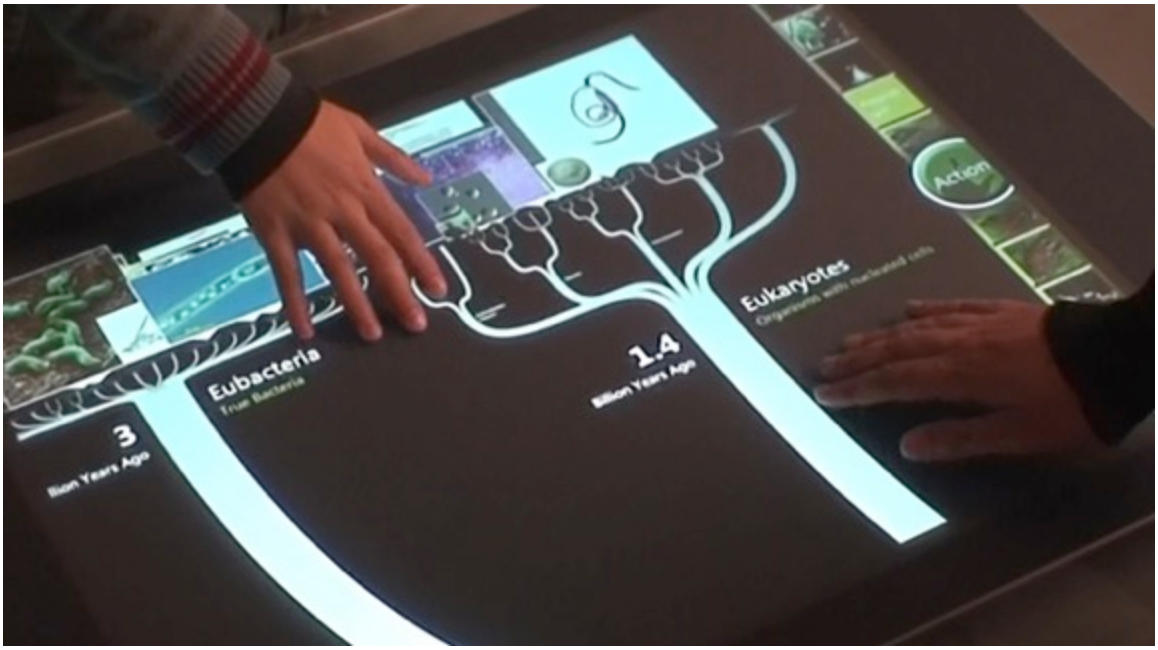

Figure 11. *DeepTree* (Florian et al. 2012)

3.2.3.4 Arctic Ice

Arctic Ice (Snibbe 2008), showcased in the California Academy of Sciences in San Francisco, is a large interactive screen display. The screen shows a mother polar bear and her baby being separated as the ice melts due to climate change. Standing in front of the screen, interactors can make full-body gestures to try to cover the sunrays and prevent global warming within the episode so that they can reunite the polar bear family. A thermometer is displayed on the screen, which shows the temperature going up and down based on the interactor's ability to block the sunlight. If interactors can't block the sunrays, they see the ice melt and the baby polar bear gets stuck on a separate piece of ice far away from its mom. While the interactor's mere gesture to cover the sunrays cannot really prevent global warming, it remains a playful experience that empowers visitors to take part in the dramatic story.

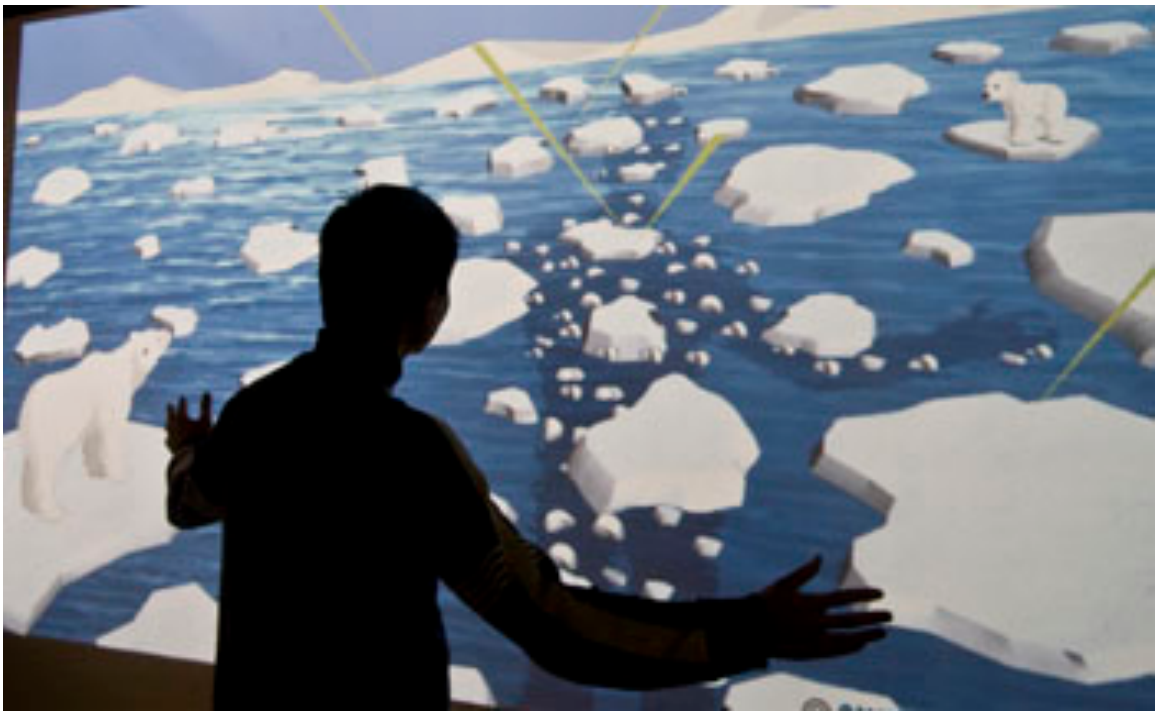

Figure 12. *Arctic Ice* (Snibbe 2008)

3.2.3.5 Skin and Bones

Skin and Bones (2015) is an Augmented Reality (AR) application in the Bone Hall gallery at the Smithsonian National Museum of Natural History. Visitors can point a mobile device toward a skeleton among many skeletons that are displayed, to activate 3D-animated scenes of the past that show the living creature to which that bones belonged. The animated scenes help visitors imagine the life of the animal (what it looked like, how it moved, etc.) represented by the artifact on displayed beyond what is being shown. For example, on the screen that the interactor is holding, the interactor can watch a vampire bat skeleton pull itself off the mount and fly away inside the screen, or see a creature crawling in one's palm when one holds one's palm behind the screen.

Figure 13. Visitor interacting with the *Skin and Bones* (2015) application

3.2.3.6 The Hague and the Atlantic Wall

The *Hague and the Atlantic Wall: War in the City of Peace* (Marshall et al. 2016) was exhibited in Museon, the museum for science and culture in The Hague, Netherlands. It

utilizes six smart replicas of objects (e.g., tea bag, sugar packet, travel pass, arm band, mug, dictionary), which provide information from the perspectives of different groups of people, spoken in different languages (Dutch, German, and English) in addition to the general written information. The objects are associated with episodes from a chosen person's perspective on the building of the Atlantic Wall in the Hague by German forces as a line of defense during WWII. For example, the blue mug was given as a Christmas gift to German soldiers; thus, it is utilized to represent a German soldier's perspective. Visitors can carry the objects around which they can place in interactive kiosks to hear an audio of the story in the voice of a German soldier, or a civilian, or a civil servant about their experiences of the construction of the Atlantic Wall.

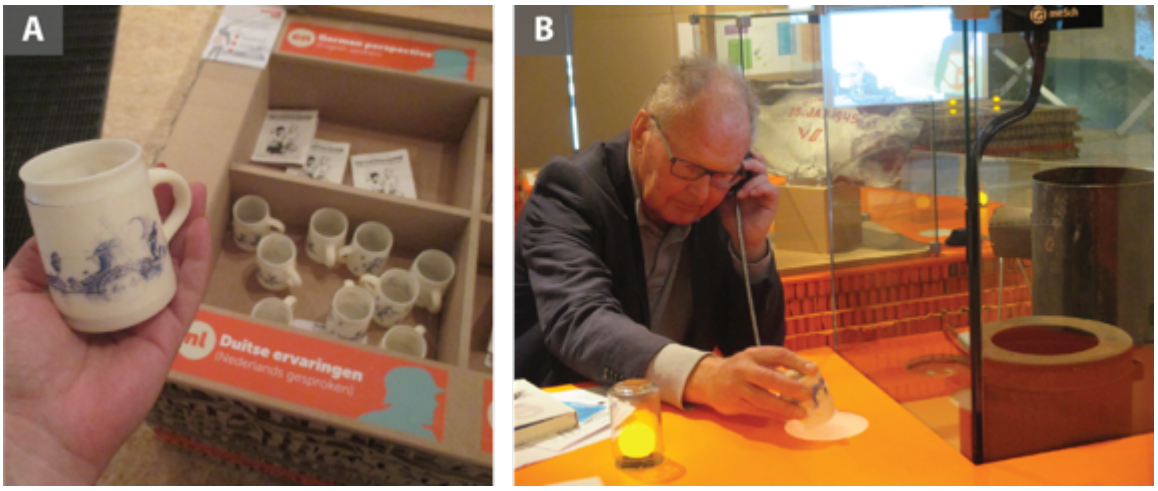

Figure 14. Visitors interacting with the smart replicas (Marshall et al. 2016)

3.2.3.7 The Whispering Table

The *Whispering Table* (The studio GreenEyl 2009), an installation exhibited at the Jewish Museum in Berlin, provides ceramic tablewares to listen to a dialogue about culinary

traditions and rituals of two cultures (Moroccan, Persian) and two religions (Jewish, Buddhist). It consists of a large, round table with several ceramic tablewares. When each dish is lifted up and held near the interactor's ear, the dish plays a recorded audio of a narrator discussing a particular traditional food – telling stories about that food and explaining its symbolic meaning. Each dish has a different narrator telling a number of stories, and each time the interactor picks up a dish, the narrator tells a different story. The act of holding the dish close to one's ear is similar to listening to a person whispering to share his or her culture or religion through the food, inviting the interactor to join the dialogue. The design team shares that the motivation for the installation was to create a participatory spectacle, which is a situation the interactor would enter into, and become a part of, thereby generating an interaction. Being surrounded by other museum goers at a dinner table helps interactors imagine that they are ready to be served by the host and reminds them of their own culinary culture. The installation is able to create a dialogue between the installation and multi-cultural visitors.

Figure 15. The *Whispering Table* (The studio GreenEyl 2009)

3.2.4 Summary: Related Museum Projects

Examining related museum projects showed how digital media systems can be designed to integrate embodied interaction with narrative. Museum projects provide visitors with an immersive experience as do non-museum projects (e.g., games). However, they provide only limited opportunities for visitors to interact with the artifacts.

3.3 Conclusion: Non-Museum and Museum Projects

Examining both non-museum and museum projects sheds light on the design direction of museum projects that utilize a more diverse set of tangible and embodied interactive modalities, which can be designed by emulating successful non-museum projects. Non-museum projects provide ideas for experimenting with a range of sensory, gestural, and immersive experiences that can engage interactors within a narrative environment. While

museums have been implementing digital technologies to help visitors engage with the story of the exhibit through interactive installations, they are more focused on delivering information. There is potential in utilizing more diverse interfaces that can enable visitors to have tangible and embodied interactions with museum artifacts.

3.3 Interactor's Embodied Experiences with Narrative

My examination of the above related non-museum and museum works led me to identify three types of experiences of an interactor with an interface as he or she engages in a tangible and embodied interaction with it. First, the interactor is situated in a narrative environment; second, the interactor assumes and plays a narrative role; and third, the interactor makes narrative interpretations. These experiences of the interactor are discussed below.

3.3.1 Situated in a Narrative Environment

Tangible and embodied interaction constructs a narrative environment, where the interactor can be *situated* within real time and space. A narrative environment is a space in which stories can unfold. A story in a tangible and embodied narrative is not just an imaginary construct. Different from a text-based medium, tangible narrative surrounds the interactor with a narrative environment that is realized in the physical space and time of the interactor.

In tangible narrative systems, digital media are utilized to create a narrative environment realized in a hybrid space and time that integrates the physical space of the interactor with the virtual story. Tangible objects, multi-modal cues, and hybrid (e.g., physical and

digital) space are mapped with corresponding narrative elements to represent a narrative environment. Several elements such as location, time, tactile feedback, sound, physical objects, and screen videos can be utilized to indicate the narrative situation and to enable interaction with the story.

The project *Reading Glove* provides an example of a tangible interaction showing how the interactor is situated in the virtual world. The *Reading Glove* provides objects which the interactor can hold to listen to the audio tape. By hearing the story in the audio tape, the interactor is reminded what happened to the spy. It is this particular interaction that is not accounted for, in Ryan's conceptualization.

3.3.2 Playing a Narrative Role

Through tangible and embodied interaction, the interactor plays a narrative role (i.e., first-person-, omnipresent- or other narrator, actor, focalizer). Tangible and embodied experience offers the interactor the ability to engage with and make changes in the story, thereby providing him/her motivation, expectation, and outcome of the story. While the common notion of interaction design considers a transparent interaction as ideal, from a tangible narrative system, the additional process of having to wear a glove or use a gadget seems to prepare interactors to play certain roles. For example, holding a gun may motivate and strengthen the interactor's emotional investment to act as a shooter.

Tanenbaum (2010) states that the physical traits of objects, such as the texture of a hammer, can support contemplating on the role of the interactor in a narrative, by reminding the interactor about the use of the object and characteristics of its owner within a story. According to Tanenbaum, an embodied interface consists of not just a functional

representation to connect with digital information, but it can be a physical representation that reminds interactors of their narrative roles. In tangible narrative systems, this narrative role is assumed not only conceptually relating to an avatar in the virtual domain or a narrator, but also through the interactor's physical performance and action in the narrative environment. Different types of physical layouts, gestures, props, sensory feedback, or rules of a game system can be utilized to allow interactors to experience the story through their physical bodies.

The *Universal Threshold Object (UTO)* project is an example of a tangible interface that associates the interactor with a narrative role. An ambiguously shaped interface serves as a remote control with which the interactor can point to a hallway on the screen to navigate or make gestures to change the story. Through the *UTO*, the interactor can play the role of an internal member, e.g., the betrayed wife, and make decisions about the story.

3.3.3 Making Narrative Interpretations

Interaction that is realized in real time and space not only engages the interactor within the story, but also provides context for interpretation through grounding narrative comprehension to a tangible and embodied experience with a narrative perspective. In various ways, tangible interaction provides context to make meaning of the story through cues, or grounding narrative comprehension to a tangible and embodied experience with a narrative perspective. In a tangible and embodied narrative, interacting with a narrative role in a narrative environment triggers related memories and thoughts that remind one of the narrative context. In tangible narrative systems, physical traits such as texture, color,

sensory experience, or digitally created responses through screens provide direct cues to the interactor to interpret the story. They also evoke related experiences and imaginations in the interactor to further support his/her comprehension of the story. The interactor makes sense of the story by interpreting the meaning cued through tangible and embodied experiences or assigning meaning to his/her thoughts that are evoked. In the ways that tangible interaction can evoke narrative interpretations, interaction can be identified as shaping the interactor's sense-making process of narrative.

The *Tangible Spatial Narratives* provides an example of how tangible interaction evokes narrative interpretations. Tangible pawns placed around the spatial environment of a tabletop represent different points of view that an interactor can assume to examine the story. Moving the different tangible pawns around the tabletop, the interactor can grasp the complicated narrative consequences.

3.3.4 Summary

Interactive interfaces of non-museum or museum projects provide interactors with a tangible and embodied engagement. They achieve this engagement to different degrees, by (1) situating the interactor in a narrative environment, (2) making the interactor assume and play a narrative role, and (3) enabling the interactor to make narrative interpretations. In the following section, I show how Ryan's conceptualization of these three experiences is not physical and tangible because the interactor's immersive experience is only an imagination constructed in the interactor's mind.

3.4 Ryan's Framework

Chapter 2 discussed Ryan's (2015; 2006) concept of immersion and interactivity within the virtual storyworld. It discussed how the interactor is transported to the virtual world, how s/he relates to an avatar in the process of immersion, and how s/he fills in the gap of the incomplete virtual world through his/her own background experience and imagination. However, Ryan's framework describing *internal vs. external* and *ontological vs. exploratory* interactions (see Ch. 2) does not allow the interactor to have actual physical experiences. While Ryan's concept of immersion and interactivity relates to the above-mentioned three experiences of the interactor with narrative, it does not consider how the tangible and embodied experience can contribute to these experiences because she focuses on narrative not as a physical experience, but as a mental construct that takes place in the interactor's mind.

For example, when we map the two non-museum projects, *Tangible Spatial Narratives* and the *Reading Glove,* using Ryan's (2006) framework, we detect no difference between the two projects, since they both would be categorized within the *external-exploratory* position. These examples highlight the different physical modalities to engage with the story. *Tangible Spatial Narratives* utilizes pawns that operate on a conceptual level to support the interactor's reasoning with the dynamics of the story. In contrast, *Reading Glove* uses real-world objects that appear in the story to help one imagine entering the real time and place of the story. In both projects, interactors play the role of an external narrator to navigate the story. However, they utilize objects in different ways to reason with, or to imagine themselves within the space and time of the story. Ryan's framework does not fully describe these differences of physical modalities to help interactors interpret the story.

Two other projects, the *Universal Threshold Object* (*UTO)* and the *TViews Table Role-Playing Game* (*TTRPG),* mapped through Ryan's (2006) framework show that both projects provide an *internal and ontological* experience because the interactor identifies him/herself as a member of the fictional world who has the ability to alter the ending of the story. The *UTO* does this by utilizing gestural interactions that provide a first-person experience, and the *TTRPG* does it by utilizing color-coded tangible pawns with which the interactor can identify. In the *UTO,* the interactor can navigate him/herself within a scene by changing the direction of the interface which functions as a flashlight in the fictional world. In contrast, in *TTRPG,* the interactor moves the pawns around the map to navigate within the story. Both *UTO* and *TTRPG* can be described by Ryan's categories of *internal* and *ontological.* However, Ryan's classification of *internal vs. external and ontological vs. exploratory* spectrum merges the interactor's identification with a *perspective* in the story and the interactor's *physical embodiment* of an avatar who holds that perspective. The *Tangible and Embodied Narrative Framework* (*TENF)* that I propose in Chapter 4 distinguishes between that narrative perspective and physical embodiment.

Overall, in the examples cited above, Ryan's framework describes only the narrative perspective (*internal vs. external*) and activity (*ontological vs exploratory*), but it does not describe how interactors utilize their physical experiences with which they relate to the story. That is, her framework does not provide the *diegetic vs. non-diegetic* modes of interaction. It focuses on the interactor's mental process of immersion, disregarding the physical experience of interactivity.

A more comprehensive framework for tangible and embodied narrative can be designed to describe the diverse types of tangible and embodied interaction with narrative. The initial components of such a framework appear in research by Harley et al. (2015). To derive a framework for tangible narrative systems, Harley et al. examined existing tangible narrative systems using Murray's (2017) concept of "diegetic" together with Ryan's (2006) framework (Harley et al. 2015).

Chapter 3 compared related non-museum and museum projects and examined Ryan's conceptualization of immersion and interactivity, as well as its limitations in discussing tangible and embodied experience with narrative. This examination has shown the need for a comprehensive framework that encompasses the growing number of narrative installations which engage the interactor physically to experience and take part in stories through the embodiment of tangible narratives.

CHAPTER 4. TANGIBLE AND EMBODIED NARRATIVE FRAMEWORK

This chapter presents a new framework to guide the design of interactive experiences in museums. Section 4.1 introduces the *Tangible and Embodied Narrative Framework (TENF*) by extending Ryan's (2006) conceptualization. The proposed framework adds another spectrum (*diegetic vs. non-diegetic*) to Ryan's *internal vs. external* and *exploratory vs. ontological* spectra. Incorporating this additional spectrum can be useful in describing interactors' diverse tangible and embodied experiences with narrative in interactive systems. Section 4.2, maps three related museum and non-museum projects using the *TENF*.

4.1 Tangible and Embodied Narrative Framework

The proposed *Tangible and Embodied Narrative Framework* (*TENF*) can serve as an analytical tool to position the interactor's experience within an interactive narrative. It can inform the design space for tangible and embodied interaction that supports narrative interpretation and provides insight into the generation of design for new kinds of narrative interactions. The goal of the *TENF* is to enable designers to include tangible and embodied interaction within a museum exhibit so that visitors can comprehend the cultural context of an artifact or installation through interacting with them. The *TENF* was not formulated to cover diverse types of tangible and embodied narrative, such as collaborative activities, story creation, or author/interactor dynamics. Rather, the

framework is intended to describe interactions with narrative representations, which make it suitable as a toolkit for analyzing museum installations.

The proposed *TENF* offers the potential for interactors to engage with a tangible and embodied narrative based on three sets of spectra: *diegetic vs. non-diegetic, internal vs. external,* and *exploratory vs. ontological*. Two of these spectra, *internal vs. external,* and *exploratory vs. ontological*, are derived from Ryan's framework; the additional spectrum, *diegetic vs. non-diegetic*, is added to describe interaction in a narrative environment (see Figure 16).

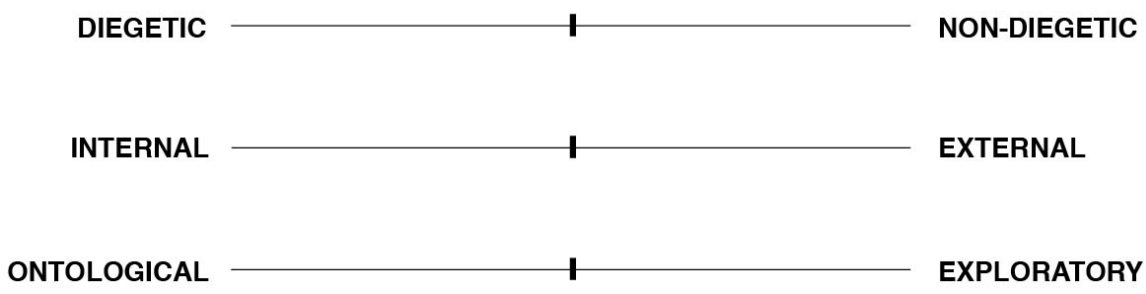

Figure 16. Tangible and Embodied Narrative Framework

The proposed *TENF* serves as a useful model for designing tangible and embodied narrative interactions with artifacts or installations that represent cultural heritage. Below, I discuss the three spectra included in the *TENF*, beginning with the *diegetic vs. non-diegetic* spectrum that I propose to add in order to create a comprehensive framework that captures interactors' embodied engagement with narratives.

4.1.1 Diegetic vs. Non-diegetic

First, the *diegetic vs. non-diegetic* spectrum (see Figure 16) describes the way narrative environment is represented (through *embodiment* of the interactor), which determines the physical modality of interaction and describes the interactor's position as he or she interacts within the narrative environment. The *diegetic vs. non-diegetic* interaction can be distinguished by whether the interactor can physically situate him/herself within the story. An interaction is *diegetic* when a tangible and embodied interaction (e.g., with an artifact or an installation by taking a certain action or making a certain gesture) motivates the interactor to immerse him/herself (i.e., project his or her body) in the context (time and place) of the story. The interactor's actions directly influence the story as if s/he had a physical presence in the time and place of the story. The interactor gains agency from his/her ability to move around and interact with the narrative environment through firsthand experience. An example of an interface that evokes diegetic interaction would be a race-car game which the interactor can control through a wearable or VR interface and have an experience close to that of actually racing, and feeling as though s/he were really driving the race car.

A tangible and embodied interaction is *non-diegetic* when it is limited to symbolic representations of narrative elements which the interactor conceptualizes to interact with and interpret the story, without being transported to the time and place of the story. In a *non-diegetic* interaction, the narrative environment is a conceptual representation of the story such as a map, narrative structure, or character dynamics. The interactor can manipulate these symbolic forms through the physically represented narrative environment. The interactor gains agency with his/her ability to access, manipulate, navigate, or organize the story through abstract representations. An example of an

interface that evokes *non-diegetic* interaction would be a race-car game, in which the interactor utilizes a remote control that simulates driving a race car seen on the screen, without really driving the car. In this *non-diegetic* situation, the interactor is fully aware of being outside the race car. Another example of an interface that evokes a *non-diegetic* interaction would be story blocks or puzzles that the interactor can manipulate in order to alter the plot.

4.1.2 Internal vs. External

The *internal vs. external* spectrum (see Figure 16), from Ryan's (2006) framework captures the interactor's narrative perspective in the story. While the *diegetic vs. non-diegetic* spectrum involves the *embodiment* of the interactor distinguished by whether the interactor can physically situate him/herself within the story, the *internal vs. external* spectrum involves a *mental* identification of the interactor with a narrative perspective. Ryan defines an *internal* interaction as one in which "users projects themselves as members of the virtual world by identifying with an avatar, who can be shown from either a first-person or a third-person perspective" (Ryan 2006: 108), such as playing the role of a race car driver. In an internal interaction, the interactor becomes an actor or a witness of the events, thus focalizing and interpreting the events in the story from a-first person perspective. An example of an internal mode would be the interactor playing the role of a protagonist in the story to invervene on events, or following the story to focalize and become a witness of events.

Ryan defines an *external* interaction as one in which "users are situated outside the virtual world. They either play the role of a god who controls the virtual world from

above, or they conceptualize their own activity as navigating a database" (Ryan, 2006: 108). In this case the interactor does not have an insider's, first-person, perspective. S/he only has access to ascertainable information related to the happenings of the story. S/he may impart an avatar's thoughts and feelings within the story, but would not be identified with an avatar within the story. An example of an external mode would be listening/viewing to the narration of a story through navigating a database, or creating a story as god would, through character dynamics.

4.1.3 Ontological vs. Exploratory

Ryan's (2006) *ontological* vs. *exploratory* spectrum (see Figure 16) captures how the interactor interacts with the story's plot. Ryan (2006) explains a type of narrative engagement as *ontological* if the interactor's actions result in altering the events that influence the raw materials of the story; and *exploratory* if the interactor navigates the story to influence the organization of the story being told (see Chapter 2).

The *ontological* mode offers the interactors' actual participation to change the story. As a protagonist or as the creator of a story or when playing any other role, the interactor takes actions or decisions that lead to forking paths in the story. An example of an *ontological* experience would be assembling tangible puzzle blocks that represent narrative events or characters, to generate stories.

In contrast to the *ontological* mode, in an *exploratory* mode, as the interactor interacts, he or she has access to different parts of the story and chooses his or her own navigational path, though without the ability to alter the outcome of the story. An example of an *exploratory* interaction would be handling tangible pawns to choose the point of view and

location on a map to view stories from multiple points of view, but not intervene on any of the events in the story.

4.1.4 Summary

Section 4.1 above modified and extended Ryan's (2006) framework by adding the engagement of the interactor with narrative representations through his or her body (*diegetic vs. non-diegetic*). Ryan's framework (*internal vs. external* and *exploratory vs. ontological* spectra) only describes how the interactor relates to the story mentally, in his/her imagination. This additional spectrum describes how the interactor relates to the story physically. The *Tangible and Embodied Narrative Framework* can help analyze various projects that extend to the physical realm beyond the virtual world represented in the screen.

4.2 Mapping Projects on the *Tangible and Embodied Narrative Framework*

These three spectra (*diegetic/non-diegetic, internal/external, exploratory/ontological*) can be used to map any tangible narrative project according to how it falls across each spectrum (see Figure 17). Thus, eight new combinations of *diegetic, non-diegetic, internal, external, exploratory, ontological* can be generated, with each combination representing a different type of narrative engagement. The selected projects – The *Universal Threshold Object* (*UTO), Whispering Table,* and *Tangible Spatial Narratives* – diagrammed and discussed below illustrate three of the potential eight combinations of the types of interactive experiences an interactor can have with the interfaces of these projects.

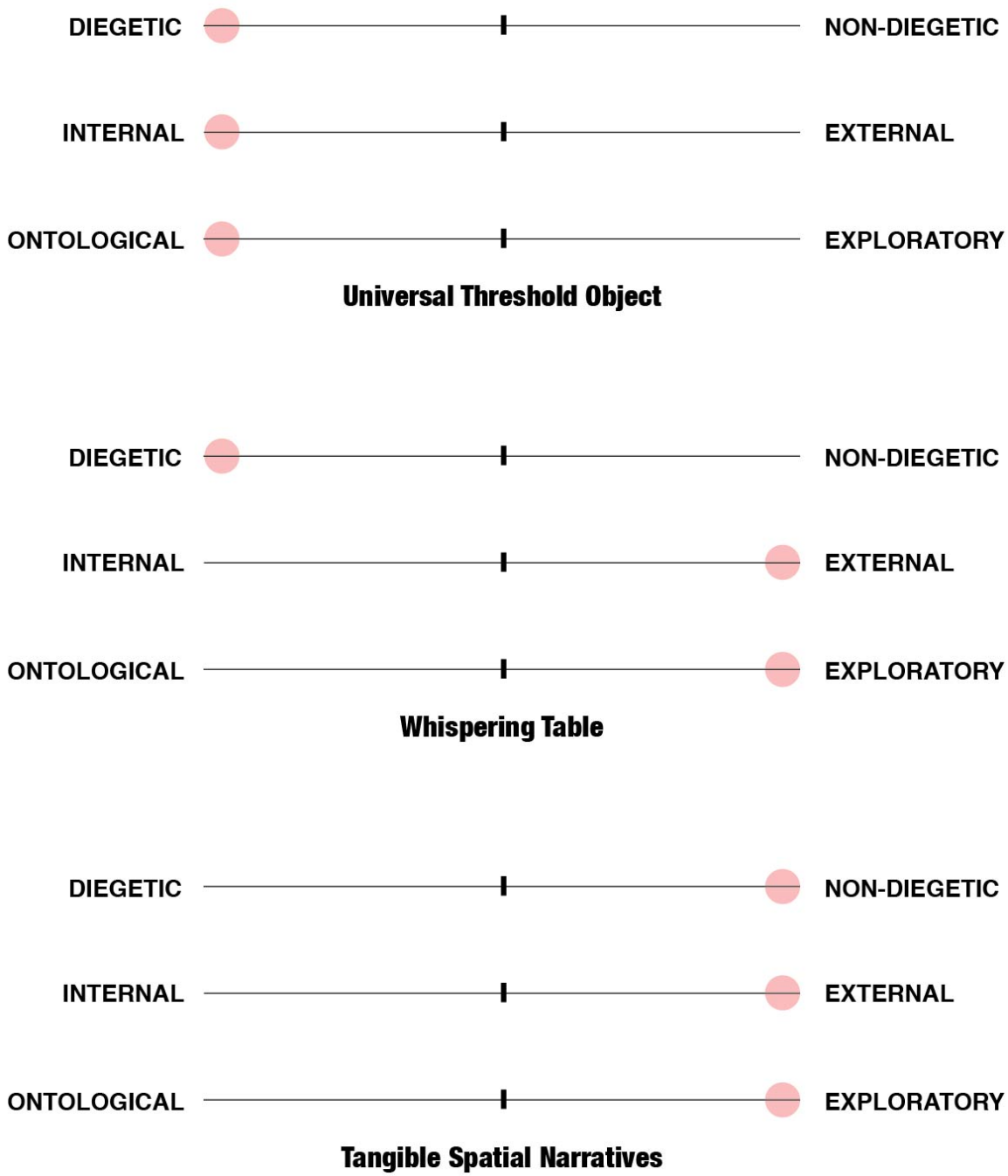

Figure 17. Mapping of projects to the framework spectra

4.2.1 Universal Threshold Object (UTO)

Among non-museum examples of related works is the *Universal Threshold Object* (*UTO),* which illustrates *internal, ontological,* and *diegetic* spectra in the *TENF* (see Figure 17). The *UTO* falls within the *internal* spectrum because it provides a first-person experience of the story and it falls within the *ontological* spectrum because the interactor can change the story by making certain gestures; and as suggested in the proposed *TENF* framework, the *UTO* is also *diegetic* because the interaction involves live action role-playing in which the interactor uses his/her gestural actions to interact with the story as if s/he were a member of the story. The *UTO* interface helps the interactor realize his/her role and provides feedback through the visual screen or haptic cues to reinforce the interactor's immersive experience. As a *diegetic* interface, the *UTO* functions as a flashlight or a rope in the story; using these objects, the interactor can make gestural actions to make changes to the story as if he or she were acting within the story (see also Section 3.2).

4.2.2 Whispering Table

Among museum examples of related works is the *Whispering Table*, a 2009 exhibit at the Jewish Museum in Berlin, which illustrates *external, ontological,* and *diegetic* spectra in the *TENF* (see Figure 17). The *Whispering Table* falls within the *external* spectrum because the interactor takes the position of an external focalizer who is listening to various narrations. The interactor does not actively take part as a member in the conversation or event, but examines and listens *afterward,* where the interaction is conceptualized as imaginatively recalling the details of the story. The *Whispering Table* also falls within the *exploratory* spectrum because the interactor listens to parts of stories without making changes. The interactions are also *diegetic* because they allow the interactor to imagine him/herself within the scene depicted in the story. Holding a dish to

one's ear prompts an audio clip of stories (e.g., about a cuisine) tied to the culture to which that dish belongs, similar to joining a conversation at a dinner table. The gestural interaction of holding the dishes enriches the information being conveyed, making one feel one is part of the culture (see also Section 3.2).

4.2.3 Tangible Spatial Narratives

Among non-museum examples of related works is the *Tangible Spatial Narratives,* which illustrates the *external, exploratory,* and *non-diegetic* spectra in the *TENF* (see Figure 17). The interaction in *Tangible Spatial Narratives* is *external* because the interactor plays the role of an omniscient narrator without identifying as a member of the story. It falls into the *exploratory* spectrum because the interactor manipulates numerous tangible objects to examine the story. It also falls into the *non-diegetic* spectrum because the interface provides symbolic representation of narrative elements to promote reasoning related to the structure or logic of the story. Mapping and representing the narrated situation through the physical interface gives the interactor access to take part in and interact with the various narrative perspectives. The *Tangible Spatial Narratives* shows how an interface can be designed to support comprehension and manipulation of the complex structure of a story (see also Section 3.2).

4.2.4 Summary

Mapping selected projects on the *TENF* above illustrates how combinations of interactive experiences result in different types of interactions and highlights the *diegetic* or *non-diegetic* interactions utilized for tangible engagement with narrative. Mapping of a project allows us to see how different types of experiences are represented through

different combinations of interactive experiences in the proposed *TENF*. This type of mapping to illustrate a tangible and embodied narrative is not an exact science. However, the *TENF* can help designers differentiate among, and compare different embodied engagements of the interactor with a narrative.

Table 1 and Figure 18 show which spectra (*diegetic vs. non-diegetic, internal vs. external, exploratory vs. ontological*) the museum and non-museum projects that have been described in Chapter 3 fall under. This mapping style following the *TENF* allows for close examination the interaction methods used by the interactor to achieve *diegetic or non-diegetic* interaction in combination with *internal vs. external* and *exploratory vs. ontological* interactions (see Table 1).

Table 1. Interaction method analysis

DIEGETIC	
INTERNAL	
ONTOLOGICAL	
Universal Threshold Object	Act and steer through a haptic interface
EXPLORATORY	
Birdly	Move arms in a full-body experience with VR goggles
British Museum VR *	Navigate and look around in 360 view
Lunch Counter Simulation *	Sit at a bar stool and listen to/sense the vibration
EXTERNAL	
ONTOLOGICAL	
Arctic Ice *	Interact with one's full-body in front of an interactive screen
EXPLORATORY	
Whispering Table *	Lift objects and place on one's ear to listen to the audio
Reading Glove	Wear a glove and hold objects to listen to the audio
NON-DIEGETIC	
INTERNAL	
ONTOLOGICAL	
TTRPG	Move tangible pawns around the multi-touch tabletop
EXPLORATORY	
Hague and the Atlantic Wall *	Place objects on interactive kiosks in a museum space
EXTERNAL	
ONTOLOGICAL	

Table 1 continued	
Youtopia	Place tangible menus and select on a multi-touch tabletop
Cinderella 2000 Triangles	Assemble triangle pieces together to listen to the story
EXPLORATORY	
Tangible Spatial Narratives	Place tangible pawns around a multi-touch tabletop
DeepTree *	Multi-touch tabletop interaction with zoom- in and out
Skin and Bones *	Point mobile device toward the display and see animations
* Museum Projects	

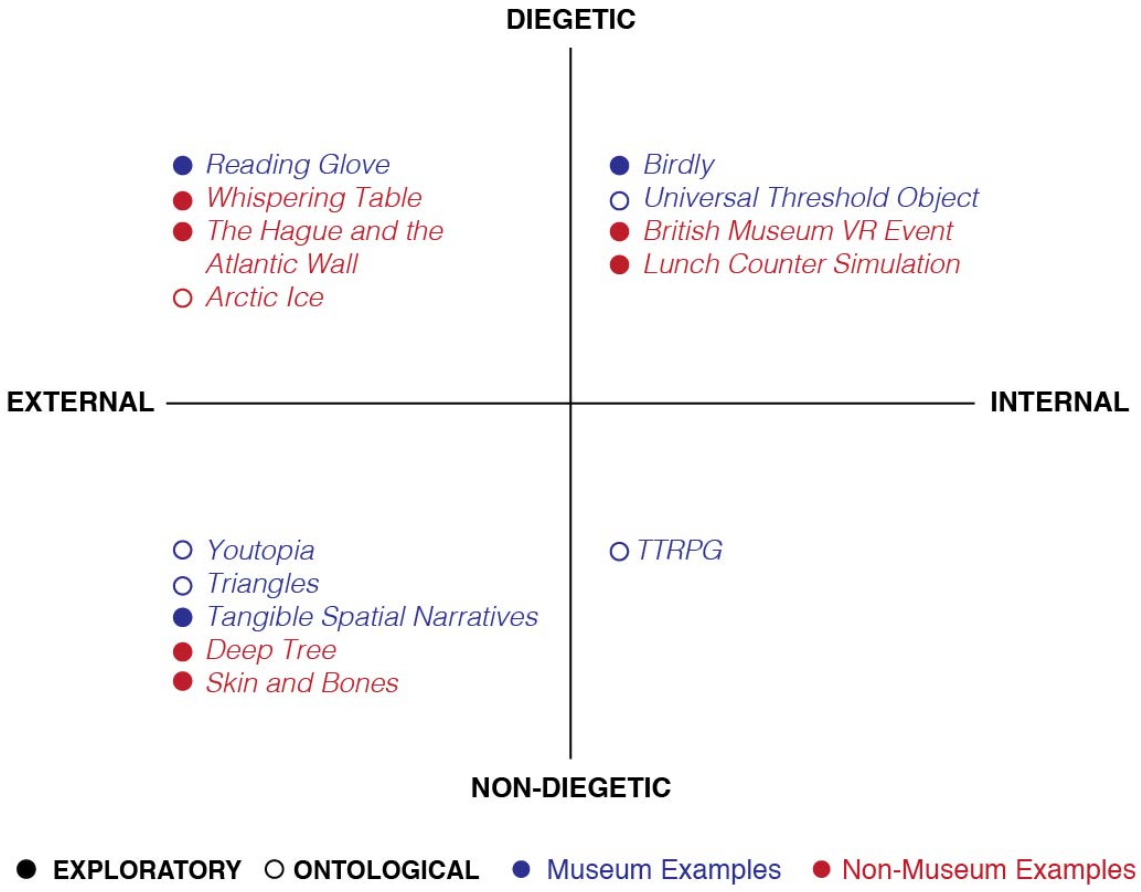

Figure 18. Mapping of related projects (Chapter 3) on the framework

4.3 Interaction Analysis: Diegetic vs. Non-Diegetic

Mapping of projects on the *Tangible and Embodied Narrative Framework* provides a detailed analysis of museum installations and insight into the direction in which future

museum installations could develop. Below, the design and impact of *diegetic* or *non-diegetic* interactions that interactors may experience with a project are described.

4.3.1 Diegetic

When visitors have a *diegetic* interaction with an interface, rich-sensory metaphors and experiences evoke thoughts and imagination related to the story, thereby allowing them to feel like they are engulfed in a scene. For example, learning more about a culture by holding a plate to one's ear or learning about history by being transported to a historic site through images, sounds, and physical sensations enriches the information conveyed to visitors. In other words, it allows visitors to have a *diegetic* interaction with an interactive interface. Through such a *diegetic* interaction, visitors can imagine being in another space and time of the story, and the information is no longer abstract, but rather, represented through the visitor's lived experience. The immersive medium has the potential to transmit stories from different cultures or places.

Technological developments such as Smart Objects, virtual reality (VR) interfaces, augmented reality (AR) applications, or wearable technology have opened up the potential for designing installations with *diegetic* experiences. VR/AR systems can provide immersive experiences so that the interactor can imagine him/herself in the story, resulting in a strong emotional reaction such as empathy, as Milk (2015) suggested in his Ted Talk documentary on virtual reality. Murray (2017) states that it is not simply technology for immersion or interactivity, but technology integrated with narrative power that can provide agency and reinforce immersion for the interactor to take part in the story. For example, an action that does not just trigger events, but also helps one imagine

being an actor in the story conveyed by an interactive system promotes a stronger form of immersion (see Chapter 2 Murray).

In addition to the immersive experience, a *diegetic* interaction has potential to place the visitor within particular perspectives of the scene to personally relate to the story. Through the diegetic interaction, interactive systems in museums can be pushed further to fully explore the potential for not only communicating information tied to objects or the interactive environment, but also helping visitors imagine themselves as being another person and witnessing events wearing the shoes of another person. Technological advancements can promote exploring the design domain.

A number of installations have been active in employing digital technology to provide a diegetic experience in museums; yet, these installations seem to be limited compared to non-museum examples, in terms of the interactivity they provide (see Table 1). There is potential to design similar installations that offer firsthand experiences like the *Lunch Counter Simulation* of the sit-in during the Civil Rights Era at the lunch counter at Woolworths in Atlanta. The simulation offers a multi-sensory experience to help the interactor position him/herself in the scene and imagine he or she were a member of the historic event – i.e., that he or she took part in the actual sit-in. While selected examples from non-museum projects such as *Birdly* provide sensory (i.e, physical) and interactive experiences, selected examples from museum projects (see Chapter 3) like the *Lunch Counter Simulation* focus on sensory experience, but provide less interactivity.

Examining the usage of interactions designed for a *diegetic* interaction can lead to design suggestions for better engaging the interactor with the narrative. A non-museum project

such as a VR game offers various immersive experiences through integrating a custom-designed tangible interface that allows for gestural, haptic, multi-sensory, or full-body interactions (as seen in the *UTO* or *Birdly*). Such projects successfully engage the interactor. They not only immerse one within the fictional world, but also allow the visitor to make gestures that have a narrative impact as if one were actively intervening within the events. Likewise, museums can explore ways to provide visitors *diegetic* experiences through tangible and embodied interactions with interactive systems so that they can relate to the cultural perspective of what's on display.

4.3.2 Non-Diegetic

When visitors have a non-diegetic interaction, physical properties of the interface promote reasoning about abstract concepts underlying the story without drawing them into the world of the story. For example, in a chess game, as the two opponents manipulate the chess pieces, they learn how to strategize. Or in *Triangles,* snapping together the image of Cinderella's evil stepmother's face with the image of Cinderella's house plays the audio clip of Cinderella's step mother yelling at Cinderella. Manipulating those elements helps the interactor identify the correlations between two triangular pieces, representing two elements (character and setting). In both examples, the interactors have a *non-diegetic* interaction with the chess set and the pieces or with the triangles. Such interactive systems with physical representations can provide interactors an active role to determine the story and promote thinking and reasoning of the dynamics of a complex structure of information.

A non-diegetic interaction can support comprehension and manipulation of the complex structure of the story. As museums usually have complex stories to tell, a *non-diegetic* interaction may enable a "kaleidoscopic narrative," a term coined by Murray (2017) that refers to a narrative comprised of various combinations of stories. For example, in *Tangible Spatial Narratives*, the interactor can flip between the perspectives of three characters who can be moved around to different locations of a miniature house, thereby having a *non-diegetic* interaction. Having a physical object the interactor can control can allow him/her to move back and forth through time and prompts him/her to focus on the changes within the time or space of the story.

While museums have actively been providing information in an interactive format, fewer examples have shown how to integrate content with physical interfaces to support non-diegetic experience with the design and construction of an interactive system such as in a chess game, or *Triangles,* or *Tangible Spatial Narratives.*

Cultural history museum installations have been actively employing a tangible token one can carry around and place on different interfaces around the museum to access an additional layer of information. Such tokens can provide a personalized experience to visitors and may offer information to be transformed as an inhabited experience. Non-museum projects provide tangible objects and interaction that can be assembled, manipulated, or arranged in particular ways to generate or navigate through stories, that museum installations can emulate. Examination of non-museum examples may offer inspiration toward possible design spaces for creating *non-diegetic* experiences that integrate the physical narrative environment to support interpretation of a story beyond simply zooming in and out.

4.3.3 Summary

The framework has been illustrated through mapping the selected projects to the spectra, showing diverse types of interactive experiences. Analyzing and mapping museum and non-museum projects through the proposed narrative framework provides insight into the design decisions and the pros and cons of certain types of experiences and interaction design ideas. It allows for close examination of the interfaces utilized for experiences. It suggests that gestures or interfaces can be designed in various ways to engage with the story in museums that emulate non-museum projects.

4.4 Conclusion

This chapter presented the proposed *TENF* model to describe the various ways tangible and embodied interaction with narrative can be designed. The model maps the design of the narrative environment within *diegetic/non-diegetic, intern/external,* and *ontological/exploratory* interactions. The proposed framework expands Ryan's framework for interactive narrative by adding the *diegetic-non-diegetic* spectrum to embrace physical interaction within a narrative environment as a method of engagement and sense-making.

Mapping various projects using the *TENF* helps to analyze an interactor's *diegetic* and *non-diegetic* interactions with narrative. The *TENF* can be used to describe and analyze interactive experiences in ethnographic and cultural history museums. Doing so can convey more in-depth information about an artifact and its cultural context. The *TENF* may also be used to inform design decisions in creating tangible and embodied narratives.

CHAPTER 5. CASE STUDIES

Chapter 5 describes two case study projects, the *Mapping Place* (Case Study 1, 2013-2015) and the *Multi-Sensory Prayer Nuts* (Case Study 2, 2014-2016), which were designed to show the potential use of tangible and embodied interaction with cultural heritage. These projects were created by a team of graduate students in Synlab under the direction of Ali Mazalek at Georgia Tech and Ryerson University. I participated in the visual design, interaction design, user evaluation, presentation, and publication of the conference papers for both projects. The projects started with a similar goal: to provide embodied interaction with artifacts to visitors to enhance their understanding of each artifact's context and meaning. While assisting in the design of the first case, I was inspired to formulate the *Tangible and Embodied Narrative Framework (TENF)* that I propose in this dissertation. The *TENF* in turn, informed an alternative design method for the second case in terms of how a tangible interaction would be utilized to engage with the story and as a means of sense-making. Both cases illustrate the design potential of the proposed *TENF*.

5.1 Case Study 1: The Mapping Place

The *Mapping Place* (2013-14), an interactive tabletop, was displayed in the exhibition, "Mapping Place: Africa beyond Paper," from February 28th to June 6th, 2014 in the Robert C. Williams Museum of Papermaking at Georgia Tech. While the main gallery showcased various African maps by Western cartographers from the 18th century, the *Mapping Place* created a digital experience of the *Lukasa* board, an African artifact, to highlight the differences in African and Western notions of mapping practices. The

project was supported by the Ivan Allen College as part of the Africa Atlanta 2014 Initiative and was designed in consultation with Lubangi Muniania, former Director of Education at the Museum of African Art in New York. I joined the *Mapping Place* project as a first-year Ph.D. student.

The project took two years to develop and create. We developed our initial idea in Fall 2012; we designed the interaction and narrative in Spring 2013; we developed the system in Summer 2013; and we iterated, conducted the initial usability test, and made changes in Fall 2013. The final project was installed and exhibited in Spring 2014, and the findings were published in a conference paper (Chu et al. 2015) at the *Tangible, Embedded, and Embodied Interaction* conference in Spring 2015. The project involved multiple doctoral and master's students in the Departments of Digital Media and Industrial Design at Georgia Tech and Ryerson University. Paul Clifton, the project lead, developed technical solutions for creating an interactive surface. Jean Chu (myself) worked on the visual design and interaction design while serving as a main contributor on researching and evaluating the user experience throughout the project stages. Chris DeLeon worked on programming through Unity; Yuan Yuan Lin worked on the physical design and fabrication as well as interaction design; Daniel Harley and Jordanne Pavao contributed to evaluating the user study and publication of the results; Ali Mazalek was the advisor and oversaw the project goals.

The goals of the project were to (1) create an interactive installation using digital and tangible media to simulate the traditional practice of mapping history and place in the Congo and to (2) better understand how digital and tangible interaction technologies can support learning and comprehension of cultural material and concepts within a museum

context. In addition, since the museum has a significant number of elementary school visitors, we endeavored to design an application that could support student group interaction.

5.1.1 Project Description

Figure 19. *Lukasa* board loaned by the Royal Museum for Central Africa for the *Mapping Place* exhibition (left) and by Brygg Ullmer (right)

The project emulated a *Lukasa* board, a mnemonic device used by the Luba people in the Congo. A *Lukasa* board is a hand-sized wooden tablet, usually studded with beads and shells (see Figure 19). The shape, color, location, and arrangement of these ornaments on the board represent stories and are meant to help recall memories (Roberts & Roberts 1996). Although the appearance of the board holds symbolic meaning that could be loosely interpreted, the actual meaning and stories depend on the creator. The spiritual leaders in the tribe construct the board to transmit history and genealogy during spiritual rituals. The meaning of the *Lukasa* board is open-ended in a way that, as each new spiritual leader inherits the board, the details of the stories can be recreated during the ritual.

In the *Mapping Place,* to highlight the non-linguistic meaning-making practices of the *Lukasa* board, we created an interactive tabletop that visitors could use to tell stories about their family, friends, and neighborhood.

Figure 20. *Lukasa*-inspired tangible tabletop installation in the *Mapping Place* museum exhibition

Figure 21. Interaction around the tabletop

5.1.2 Design Walk-through

The *Mapping Place* consists of a multi-touch tabletop with tangible shells, two adjacent wall projections, and a wall-mounted television screen. To begin telling stories, visitors put the shell on the interactive tabletop, which represents a story. When the shell is placed on the tabletop, icons of story elements (girl, boy, woman, man, house, neighborhood, and a pet) are displayed. The tabletop consists of virtual beads of several different colors and shapes, which can be dragged into one of the story element categories. Once a virtual bead is dragged on top of a story icon, the bead transforms into a story-bead and a connection with a story-shell is formed (see Figure 22). A corresponding animation is displayed on a wall projection to encourage visitors to tell the stories with other people. Visitors can rearrange their story by dragging their story-shells or rearranging the connected story-beads. Once they are finished creating stories, they lift

their tangible shells up to see their story-map: story-beads with virtual icons attached to the story-shell.

Figure 22. Visitor dragging beads to icons around a tangible shell (left); wall animation (right)

Figure 23. A circular menu of icons (left) appears around a tangible shell when it is placed on the tabletop (right)

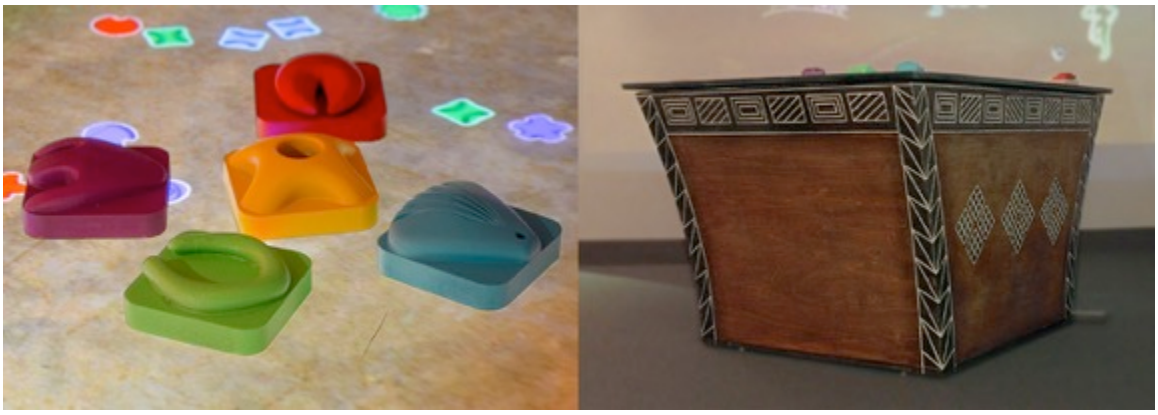

Figure 24. Tangible objects (left); tabletop (right)

5.1.3 The Design Process

The Synlab team already had experience designing interactive tabletops, which is why the Dean of the Ivan Allen College asked the lab to contribute to creating an interactive tabletop for the African maps exhibit. In this way, the design group decided on the type of interface to design: an interactive tabletop. However, we were open to what content to show through the tabletop and what types of interactions to utilize for such. We initially brainstormed several ideas, such as visitors turning a timeline to view different maps or artifacts of the Congo. However, these ideas were not effective at really engaging visitors with the cultural practices of Africa.

Lubangi Muniania, the curator at the Museum of African Art in New York, introduced us to the *Lukasa* board artifact, which clearly showed the unique ways the Luba people in the Congo mapped their own history. We then outlined different types of interactions that could potentially take place with a virtual-type *Lukasa* board. Among our ideas was to hand out small *Lukasa* boards to visitors, which they could use as magnifying glasses to garner additional information from the interactive tabletop. Envisioning the whole

tabletop as a large *Lukasa* board, we settled on the idea to empower interactors to create their own *Lukasa* boards by communicating with the interactive tabletop.

Initially, we intended the tabletop to show animations of African mythologies or folklore upon trigger of the symbols (e.g., shells, ideograms, carvings on the *Lukasa* board) on the tabletop. However, we rejected this idea, since the meaning and the stories of the *Lukasa* board were not predefined, but instead assigned and configured by the creator of the *Lukasa*-board story. Thus, it was more appropriate for the stories to be created by the interactor rather than by having interactors replay fixed stories. Revisiting the concept, we decided that dragging and dropping the beads to story icons would best represent the mnemonic process. We decided to offer generic virtual story categories and colors that the interactor can use to represent their individual stories.

We conducted an initial usability test in Fall 2013, utilizing story cards to ensure that children were able to create stories with our virtual story categories and to evaluate the usability of the preliminary design. Participants in the age range of kindergarten and elementary school students were able to build stories utilizing the provided story categories as intended. However, the children also reported wanting to be able to map additional story elements, such as time. The animation on the wall corresponded to the location of the story map on the tabletop, yet the children were confused about which animation belonged to themselves. To resolve this issue, we decided to position the tabletop diagonally toward the screen.

5.1.4 Implementation

The multi-touch surface uses Diffused Surface Illumination (DSI) with a reflective acrylic board and Infrared Light (IR) strips wrapped around the edges of the board. The multi-touch and ReacTIVision fiducials are sensed through Community Core Vision (CCV). Four Playstation™ Eye cameras are used to view the tabletop surface and are stitched through CCV.

The table was constructed with plywood from the Advanced Wood Projects Lab at Georgia Tech, which used a Computer Numerical Control (CNC) router. The tangible shells were 3D printed with plastic on a Dimension SST 768 in the Graphics, Visualization, and Usability (GVU) Prototyping Lab, and then finished by sanding and painting the surface.

The frontend was developed through a game engine, Unity3D. It receives TUIO protocol from CCV and displays corresponding animation on the tabletop as well as the wall projections. Unity3D also provides physics to animate the virtual beads being flicked and to determine the location of the displayed wall animation.

The animations were drawn using Adobe Flash and After Effects. Each frame was exported as a still image that was colored and animated through Unity3D upon interaction. The form of the table and the tangible shells were designed through Solid Works.

5.1.5 Evaluation Process

The project was evaluated in two ways: by exposing the project to the public and conducting a controlled user study with hired participants at the design space. During the

exhibit in the museum, visitors, usually elementary school children, would first encounter the Western maps, then they were introduced to an original *Lukasa* in a glass case, and finally they would enter the second alcove with the interactive tabletop. The tabletop was intended to let visitors further delve into the African concept of mapping and storytelling. However, unless we described our intention for the interaction and its relation to the actual *Lukasa* board, interactors often did not understand the concept and intention of the application. During the exhibit, we observed that interactors with the tabletop went back to look at the original *Lukasa* board, since they did not understand the interactive component's relation to the *Lukasa* board. Many visitors utilized the interactive tabletop as an application for telling stories, without drawing connections to the actual board. We speculated that this gap was due to the difference in cultural assumptions behind stories and maps from Westerners and the Luba people.

In order to further investigate whether visitors were connecting the interactive tabletop to concepts from the *Lukasa* board, and to examine how visitors utilized the interactive tabletop itself, we conducted a user study. We did so by inviting fourteen participants to the museum, 8-13 years old, four females and ten males. Eight were homeschooled children and seven were elementary school students.

In the user study, we gave a ten-minute lesson using two different methods: (1) giving a lesson prior to the interactive task and (2) giving a lesson after the interactive task. Our goal was to investigate how the interactive tabletop primed students for learning and how they applied their understanding to their interaction. In both cases, the lesson described the concepts and usages of the *Lukasa* board. During the lesson, we shared photos and

videos of the *Lukasa* board being used by the Luba people. We also described the non-linguistic mnemonic meaning-making practice made possible by the *Lukasa* board.

The user study consisted of pre-task and post-task semi-structured interviews and a ten-minute interactive task in a gallery space to utilize the interactive tabletop. The interview posed questions before and after the lesson and interactive session in order to assess knowledge related to the *Lukasa* board. We video-recorded the interview and the interactive session and then transcribed the scripts. The transcription was then analyzed through grounded theory (Charmaz 2006) to derive emerging keywords and themes. As a qualitative analysis, grounded theory enabled observation without prior hypothesis and derived insights through examination. A qualitative analysis provided insight into the usage and effects of tangible and embodied interaction with cultural heritage.

5.1.6 Findings

The results indicate that by utilizing an activity that children were already familiar with—storytelling—the tabletop assisted with sense-making of the concept of the *Lukasa* board. By utilizing abstract forms of color, shape, location, and the arrangement of the beads, the children created a map that represented their stories. The children were able to utilize the tabletop application to make and tell stories regardless of their knowledge of the *Lukasa* board. We also wanted to know whether they were utilizing the tabletop to comprehend the concept behind the *Lukasa* board and whether the interactive experience assisted with that comprehension.

Based on results from the pre-task and post-task interviews, we focused specifically on the response that describes how the children made stories with the tabletop. Additionally,

we focused on responses related to how they describe the *Lukasa* board. We thus coded the response in two ways: those who utilize visual traits such as color, shape, and location with symbolic meaning, and those who utilize visual traits as a mere depiction of appearance without any meaning attached. After we coded the children's responses and counted how many times they mentioned the symbolic aspects, we compared how their responses had changed before and after interaction with the tabletop or learning about the *Lukasa* board, as well as how the two groups differed. We found that the interactive *Lukasa* board was useful for (1) priming visitors for learning and (2) for supporting visitors' sense-making. These two findings are discussed below.

(1) Priming for Learning

The interactive experience primed students for learning the concepts of the *Lukasa* board for the lesson. The tabletop interaction in turn allowed students to comprehend better the concept of the *Lukasa* board during the formal lesson. Consequently, their experience with the interactive tabletop provided vivid examples to which they could relate while learning about the *Lukasa* board. Following are the children's remarks during the interview about their experiences with the *Lukasa* board and the interactive tabletop.

One participant, who was exposed to the interaction before the ten-minute lesson, shared, "In Lukasa, the symbols represent things, and based on probably visual similarities. They probably make the symbol look similar to what they are explaining". This means that the participant was able to recall his/her interactive experience to understand the symbolic mnemonic meaning-making aspect of the *Lukasa* board. Another participant, who attended the ten-minute lesson first, was also able to relate the tabletop experience to

understanding concepts about the *Lukasa* board. S/he said, "[The tabletop application] helped me understand how something could symbolize things. Like for example, this boy icon can symbolize something but then I can tell different stories out of it." These two remarks imply that regardless of the order, eventually, the interactive tabletop experience helped participants make a connection between their interactive experience and the concepts of the *Lukasa* board.

(2) Supporting Sense-making

We found that the participants who received the lesson before the interactive session applied what they learned in the lesson better to their interactive experience so that they could contextualize their experience. They were thus able to create stories through the interactive experience that utilized the tangible shells and beads in symbolic ways similar to the ways the *Lukasa* board encourages participants to engage in abstract meaning-making. For instance, they used the color and location of the story-shells and story-beads to illustrate relatives, groups, and emotions when creating and telling stories during their interactions. One participant utilized the color of the story-beads to indicate emotion in her story, showing how she was utilizing the symbolic aspect of color. S/he said, "I put the lady into red because she got really angry at the baby for crying so loud." This remark clearly shows that the interactive tabletop was supportive of sense-making of the symbolic aspects of the *Lukasa* board's visual elements.

In contrast, participants who were given the ten-minute lesson after the interactive session were not able to make use of the symbolic aspects while they told stories during their interaction; for them, the interactive tabletop was just a fun storytelling application.

They made literal interpretations of the visual elements, such as how the animation looks, without describing their story through symbolic elements during their interaction. For example one participant remarked: "The man is trying to kill the cat so it is running away. Poor cat." This remark shows that this participant, who did not learn about the *Lukasa* board first, was not able to identify concepts based on the tabletop usage alone. Consequently, rather than utilizing visual elements to symbolically represent stories, participants were only using the illustrations to literally show stories.

At the same time, the interactive experience without prior knowledge showed other benefits such as the potential of leading to collaborative story construction. Due to the nature of the *Lukasa* board being a personal story construction device, prior knowledge of the *Lukasa* board seemed to limit a participant's interactive experience to only creating an individualized story. In contrast, participants who received the ten-minute lesson after the interactive session showed greater tendency to collaboratively construct stories. One participant shared the following story during her interaction with the tabletop: "You have a cat and I have a cat...We have so many cats! Now what can we do with everybody's cats?" This participant's story shows that she collectively looked at the other participants' story shells and story beads and incorporated them into her story.

5.1.7 Summary

The *Mapping Place* project showed that interactive technology could assist with sense-making of the cultural concepts surrounding a cultural heritage artifact. However, the challenge comes from the fact that people have different cultural backgrounds and make different assumptions, which can hinder the reception of the cultural concept manifested

through the interactive tabletop. Our evaluation of the two conditions of introducing the ten-minute lesson revealed that interaction priming participants with contextualized knowledge can assist them with sense-making of abstract concepts. Without prior knowledge, students were not making use of the interactive tabletop specific to the *Lukasa* board.

Designing and implementing the *Mapping Place* project led to developing the *Tangible and Embodied Narrative Framework (TENF)* to help designers create and analyze different types of designs. Reflecting on the results from our evaluation of the *Mapping Place*, our design team at Synlab conceived of a new project, *Multi-Sensory Prayer Nuts*, which can be positioned in the *TENF* in a different way than the *Mapping Place.* The *Multi-Sensory Prayer Nuts* focused on how to prime the interactors and better situate them within the native cultural perspective of a particular artifact.

5.2 Case Study 2: Multi-Sensory Prayer Nuts

In the *Multi-sensory Prayer Nuts* (2014-16) project was conducted and led by four students in Synlab at Georgia Tech and Ryerson University to imagine the potential of the design space for tangible interaction with cultural heritage in a museum. The project idea was brainstormed in Spring and Fall 2014; the design for the prototype was developed through Spring and Summer 2015; the Synlab team developed three multi-sensory interactive prototypes; the project was evaluated in Fall 2015 and published in Spring 2016 at the *Tangible, Embedded and Embodied Interactions* conference (Kwan et al. 2016) and at the *Museum and the Web* conference (Harley et al. 2016), and in Summer

2016 at the *Designing Interactive Systems* conference (Chu et al., 2016). I joined the project as a third year Ph.D. student.

The project involved doctoral and master's students from Georgia Tech and Ryerson University in the Department of Digital Media. I was the project director and participated in the overall research, visual design, evaluation; Daniel Harley was narrative and sound designer and researched the user experience; Jamie Kwan worked on physical prototyping, visual design, and user experience design; Melanie McBride served in an advisory role on the design of sensory interaction and helped to design smells for the interaction; Dr. Ali Mazalek supervised and provided overall feedback for the project.

The project was not exhibited in a museum space, and therefore did not involve any consultation with any museum professionals. The lab setting in which it was developed had limitations, such as not being able to examine the *in-situ* reactions of visitors. Nonetheless, the lab environment enabled us to freely explore potential design spaces.

The *Multi-Sensory Prayer Nuts* project goals were twofold: (1) to investigate the role of narrative in tangible and embodied interaction and (2) to provide multi-sensory interaction through the *Prayer Nuts* to provide methods on which to reflect. Specifically, we set out to investigate ways in which narrative involvement through tangible and embodied interaction can assist with interactor reflection on the cultural context surrounding particular artifacts in a cultural history museum.

5.2.1 Project Description

The *Multi-Sensory Prayer Nuts* project focused on the prayer nut, a devotional object that

laypeople used during the 16th century in the Netherlands (see Figure 25). In general, the prayer nut was meant to be portable miniatures of a sacred space, such as a cathedral. A prayer nut, as a kind of rosary, consists of two boxwood hemispheres around six centimeters in diameter with a clasp to open and close it. The interior shows intricate carvings on each hemisphere representing biblical scenes, and the exterior shows Gothic architecture. Fragrances were infused into the prayer nut or the prayer nut was used with beads made out of scented materials. The prayer nut engaged various senses including sight, touch, and smell in order to assist with religious practices. Used during personal religious experiences, the prayer nut shows the dependence of spirituality on material objects during the 16th century (Falkenburg 1999; Scholten 2011; 1999).

Figure 25. The interior (left) and exterior (right) of a 16th-century prayer nut (Image courtesy of the Metropolitan Museum of Art)

5.2.2 Design Walk-through

Based on historic texts about the prayer nut, we provided three different types of interactions, focusing on each sensory aspect in order to place the artifact in its original context and use. We created a replica of the artifact and connected it with sensors and

microcontrollers to allow interaction; we then connected it with computers, monitors, and speakers to provide audio- and video animations about the contextual information in response to interactions.

The *Multi-Sensory Prayer Nuts* project consisted of three prototypes – *Visual Voyage*, *Experiencing Spirituality*, and *Scents of Power* – each highlighting different sensory practices with the prayer nut. The first prototype, *Visual Voyage*, focuses on tactile aspects of the intricate carvings of biblical scenes in the prayer nut and how these scenes can support religious contemplation. In many ways, interacting with an actual prayer nut in a spiritual context was compared to interacting with the Bible. First, the intricate carving required a magnifying glass to view it, similar to how one might have used a magnifying glass to read Scriptures. Also, opening and closing the prayer nut was likened to opening and closing the Bible, or even the panels of a triptych (Scholten 1999).

The *Visual Voyage* prototype we designed provides a wooden sphere with carvings of biblical scenes. The surface of the prayer nut that the interactor can hold has three tactile points that can be activated upon gently touching its surface (see Figure 26). The interactor can then see corresponding Scripture on the screen relating to the carving and an enlarged carving on the screen as if s/he were contemplating an actual prayer nut using a magnifying glass.

Figure 26. "Visual Voyage" interaction (top) and projected animations (bottom)

The second prototype, *Experiencing Spirituality*, focuses on breath as a sensory-bodily aspect of prayers, and how prayers might have assisted moving from a secular place to a sacred place in the mind. In historical practice, prayer nuts were used to navigate through one's religious practices while also serving as a symbol of wealth and piety among lay people (Falkenburg 1999). In the interactive project, a screen shows a merchant from the 16th century holding the prayer nut. The design intention is to encourage the interactor to hold the prayer nut in a similar way. When the interactor holds the prayer nut, the screen

shows a close-up of hands holding the prayer nut, while one can hear the sound of breathing and marketplace noises. This is to reference that the prayer nut is used to assist one in finding peace in one's heart. Holding the prayer nut for eight seconds causes the background to change from a market scene to a cathedral, along with the sounds that change to liturgy and a choir singing (see Figure 27).

Figure 27. "Experiencing Spirituality" interaction (top) and projected animations (bottom)

The third prototype, *Scents of Power*, focuses on the belief in the magical power of the olfactory aspects of the prayer nut. During the 16th century, people put "sweet-smelling ingredients" such as herbs, oils, and dried flowers in their prayer nuts (Soden-Smith 1874). They believed such scents had magical power to ward off evil (Classen & Howes 2006). To emulate the original scents of the prayer nut, we brushed the inner surface of the prototype with essential oils, such as lavender and cinnamon. We attached the prototype to a table with a projection overlaid from the top, projecting images into the prayer nut. Opening and closing the prayer nut causes the projection to show animations of the scents (see Figure 28).

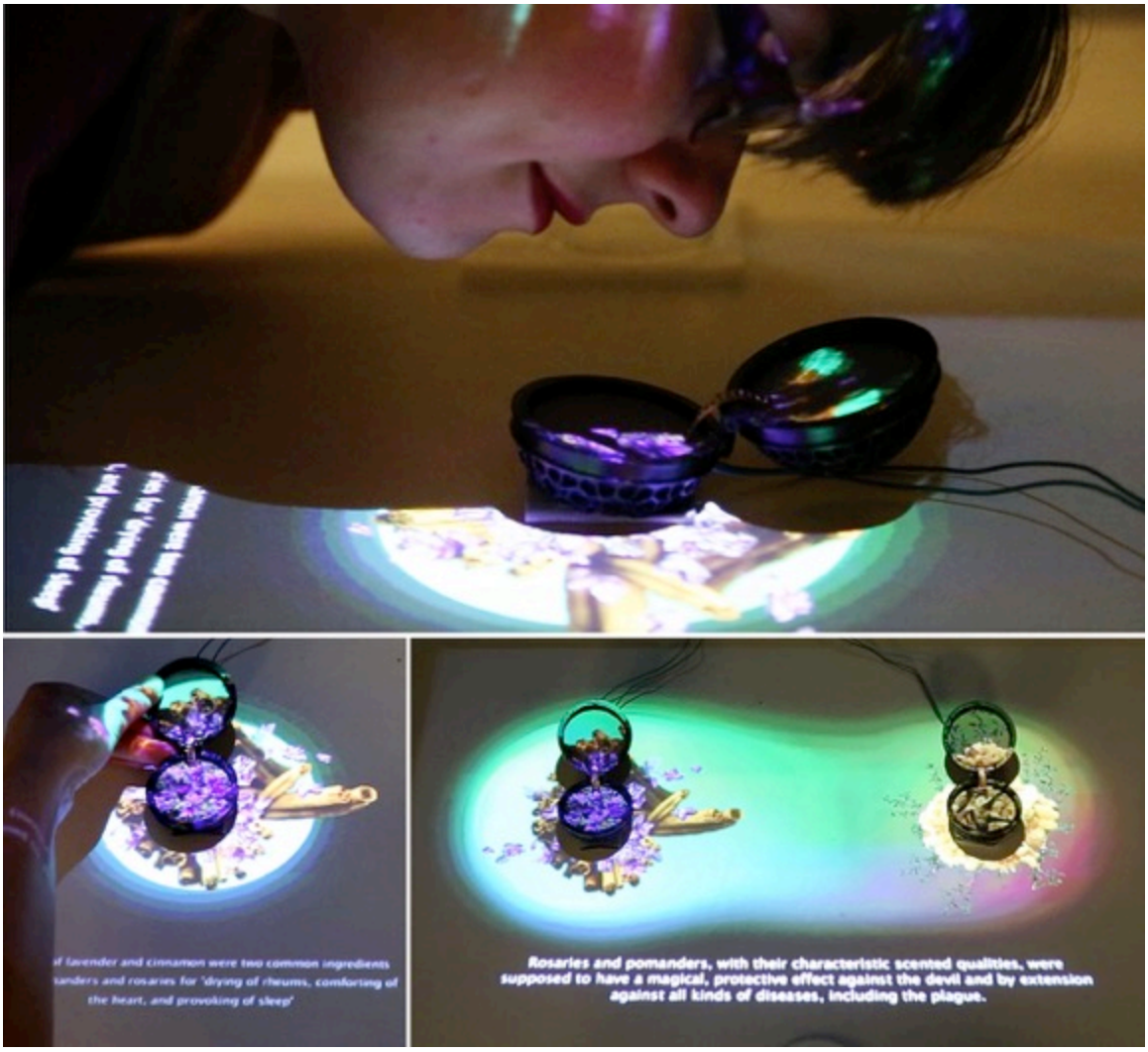

Figure 28. "Scents of Power" interaction (top) and projected animations (bottom)

5.2.3 The Design Process

The *Multi-Sensory Prayer Nuts* project was designed based on the results of the *Mapping Place* project, which only focused on the sense-making practice without grounding the participants within a narrative perspective. The main challenge highlighted by the *Mapping Place* was the fact that the interactor enters the interactive experience with different cultural assumptions. Thus, in designing the *Multi-sensory Prayer Nuts,* we

focused on giving a sensory experience with a prayer nut to interactors from different cultural backgrounds.

Since our design team did not have any restrictions dictated by a particular museum or its curator, we were free to explore many possibilities of digital media use. Fascinated by the prayer nut artifact and its potential, we brainstormed around various types of activities that can be housed within a museum environment to engage visitors. Ideas that were shared included printing the prayer nut in 3D and giving it to visitors that they could carry around; or developing a program that would draw patterns with a similar look and feel of the exterior of the prayer nut, following the pattern of visitors' voices as they prayed. However, we realized that these concepts were based solely on visual sensory engagement and we were making a narrow interpretation of the prayer nut without really grounding interactors in its cultural context and usage.

Looking at historic texts detailing prayer nut usage among lay people, we tried to provide information about the original intent for the actual prayer nut. We considered creating multiple interactive stations to give visitors various roles for engaging with the prayer nut. We decided to provide the hypothetical narrative perspective of a merchant and to focus on four senses: touch, smell, see, and hear. Since screens can provide prompts and information about the use of the prayer nut, and can help interactors engage and imagine themselves in the scene, we chose to utilize an interactive screen as the main component of the interface. We conceptualized that the screen would show the context, and, once the interactor engages, it would also provide animated scenes of the journey. Since the interaction would not be familiar to visitors, we decided that it should loosely follow a

step-by-step guide to a comfortable entrance into the narrative context and experience of the prayer nut.

We wanted to provide tangible interactions that are similar to how the original prayer nut would have been used. As the prayer nut originates from a multi-sensory context, our project highlighted different sensory interactions as means of engagement and sense-making. These interactions included opening and closing the prayer nut, smelling it, touching the surface, visually tracing the detailed carvings, and holding the prayer nut within one's palm. After brainstorming about historical gestures and their symbolic meaning related to the personal spiritual practice, we designed tangible interactions similar to those gestures and their meanings.

We showcased the first iteration of the three prototypes – *Visual Voyage*, *Experiencing Spirituality*, and *Scents of Power* – to eight colleagues in our lab for an informal user test to evaluate the usability of the prototypes. Based on observation and informal interviews, we learned that participants were hesitant to handle the tangible artifacts and also did not know what physical interactions were available. Although the screens provided textual and tactile cues to how to interact, these were not enough, and additional prompts were necessary to encourage initial interactions.

While the prototype had limitations with usability, it showed the potential for offering personal encounter with multi-sensory interaction with artifacts. Especially with the *Scents of Power*, participants compared their experiences to the fragrance in their memories. This finding led us to focus the second iteration of the user test on examining the experience of engaging with one's bodily sensory interactions with the artifact and

the potential of multi-sensory experiences for supporting interactors' interpretations of the artifact. Reflecting on these initial findings, we provided additional mimetic cues for the second iteration of the prototype and decided to provide pictorial instructions to inform the interactors on how to handle the prototypes so they were not distracted by simple usability issues.

5.2.4 Implementation

The technical limitations of having a low budget and no physical model resulted in a low fidelity replica. The prayer nut replica was modeled through the 3D software Rhino and printed using plastic. We chose a simplified version of the prayer nut in order to provide a look and feel that was sufficiently similar to the original. The first prototype, *Visual Voyage*, had relief sculpture carved into the interior of the nut. To surmount the technical challenge of intricate carving, we utilized a photographic image converted to a 3D model through software for conversion. Since this resulted in numerous glitches, we also laser-cut wood through a black-and-white photographic image of the interior.

Various types of sensors were embedded within the plastic prayer nut and connected to microcontrollers and computers. For *Visual Voyage*, we painted the surface with capacitive paint to sense touch on its surface. For *Experiencing Spirituality*, our initial idea was to use a breath sensor. However, due to the challenge of requiring the interactor to put on wearable gadgets to detect their breath, we chose other means to determine how long the interactor may be holding the prototype. The initial version used a temperature sensor; but since changes in temperature required a long time to sense and were not easy to control, we eventually decided to use a capacitive sensor. For *Scents of Power*, we

initially used a flex sensor to detect the open or closed status of the artifact. However, due to the tension the flex sensor created, we changed to a magnetic sensor.

The front end of the audio/video effects were created through the Processing program. Images were created through Adobe Photoshop or Adobe Illustrator and then animated through Adobe Flash, exported as single frame images. These images were displayed through Processing upon interaction. The sound of breathing and the market scene were also assembled through Processing.

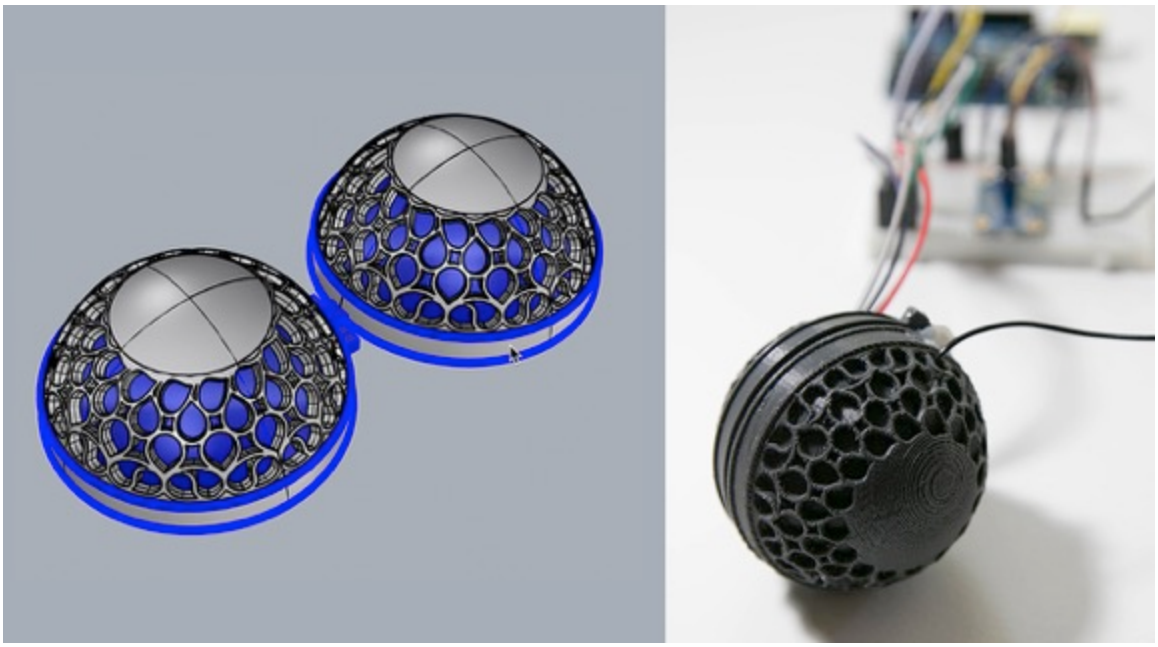

Figure 29. 3D Printing of the Prototype

5.2.5 Evaluation Process

The goal of the user test was to assess the effectiveness and impact of our narrative design and sensory interactions. Since we also wanted to see how an interactor would receive the design choice informed by the framework, we analyzed the participants'

responses toward how these choices would relate to the narrative components of the framework. The evaluation focused on (1) how participants would interpret meaning out of their sensory interaction with the prayer nut; and (2) whether situating sensory experience in a narrative context influences the way(s) participants interpret their experiences.

We evaluated the project in a lab environment with thirteen participants (eight male and five female), eleven of whom were graduate students at Georgia Tech. We invited participants in ones, twos, or threes. We conducted pre- and post-task semi-structured interviews with interactive sessions. We video-recorded the interaction, transcribed, and analyzed the interview results through qualitative methods, in particular, discourse analysis (Gee 2014).

The pre-task interview asked about the usual ways participants encounter multi-modal experiences in their everyday lives. The post-task interview prompted participants to relate how they utilized their sensory experiences to engage with and make meaning from the artifact. We asked open-ended questions such as "How did you make meaning from your experience?" Such a question required participants to talk about their experiences; we then followed up with corresponding questions to participants' responses.

The three prototypes for the interaction session were randomly placed in a triangular formation. We did not limit the time, and the participants spent on average 1~3 minutes for each prototype. In front of each interactive prototype, we created pictorial descriptions of how to interact during each session. Each prototype was accompanied by a guide on how to interact with the prototype, along with a short description of the

historical meaning of such an interaction with the actual artifact. This was to ensure the interactors would not get confused about what they were to do with the prototype. Our goal was to examine how visitors aligned their personal experience with the prototype to interpret the original artifact.

5.2.6 Findings

The evaluation results can be summarized as (1) contextualizing artifacts, (2) personalized connection and (3) limitations of the prototype.

(1) Contextualizing Artifacts

During the post-task interview, participants shared that sensory interactions with the prayer nut helped them contextualize its use by providing information that would not have been available through a simple text or visual display. This disclosure shows that sensory experience with the artifact assists the interactor in reflecting on the context of the time and place of its use. In the prototype *Experiencing Spirituality*, the multi-media installation showed the video and audio of a late medieval market place to support imagining the hypothetical time and place of the prayer nut as it was originally used. During the interview, participants reported that while they were immersed in the audio-video and sensory experience, they reflected on the people who historically used prayer nuts and their religious activities associated with them. One participant made this statement during the interview: "It is more that, if I just saw the object, I would be, 'oh, this is a pretty item to use, in the 16th century.' Instead I am like, 'oh, people would take this on the street, and maybe look at it, smell it, and this is how it made them feel'." This

comment shows that the sensory experience supported participants to imagine how the artifact was used in a specific context.

Most importantly, presenting sensory interactions within a narrative supported contextualizing the meaning of interaction through cultural perspectives. Participants took the perspective of a potential user of the prayer nut during the 16th century so they could better interpret it. This interaction was shown through participants sharing that they were able to understand 'why' the artifact was meaningful to the original users of the prayer nuts beyond just 'how' they were used. Without this narrative perspective, the interactor would have approached the artifact from a different culture without appreciating its meaning in its original cultural context.

One participant made the following observation during the interview. "By touching it, it tells you more about what the objects were really meant for... Because it is now there for you to know these things exist. It is there for you to understand how, when, and why people used these things a long time ago." This remark shows that the sensory experience triggers the participant to identify the value and meaning of the artifact based on its religious context. Another participant described how the multi-sensory experience helped contextualize the artifact: "You feel like you are actually experiencing the object and thinking about the context. The evocative illustrations, and the use of sound, all these senses... it really puts it in context and it is not just an artifact divorced from context." These interview results show that participants were motivated to imagine the artifact's use through digital effects and multi-sensory interactions with the artifact.

Some participants shared their insights into the opportunity to utilize sensory interaction to transform the museum experience and give a sense of the actual time and place for such artifacts, which most current museum displays are missing. The same participant quoted above contrasted the sensory experience to the lack of context in the current methods of museum displays: "What is important is context. Like most of the time we go in a museum, and it is really boring because things are very, very removed from their original context, and the best that museums do is put a little piece of writing next to it, that has to be really short, or no one is going to read it. And this is a good way of adding more context to the pieces."

(2) Personalized Connection

The firsthand interaction, which positioned the interactor to inhabit the space from the perspective of a historical figure, offered ways for participants to interpret their experience subjectively. The interactive experiences not only informed the use of the artifact, but also allowed participants to personalize their knowledge to relate to the thoughts and feelings of a historical figure. One participant shared the following comment during the interview: "Before, I didn't know about the prayer nut, but now I know what it is, and I know how to use it, I can feel some similar feelings with them. So it was very informative and interesting." This participant's remark shows that the experience helped her relate to the people who used the prayer nut. Another participant made utterances as if she were bridging the gap between herself and actual users of prayer nut: "As I was touching the object, I felt like I was becoming that person, because I was interacting with the object, and I was also experiencing what those people were experiencing in the 16th century. So, I felt I was experiencing that person's life as

opposed to just reading descriptions." This shows that the experience with the first-person perspective caused participants to relate to hypothetical figures, as we had intended through the design.

Furthermore, the interactions led some participants to describe their experiences by making connections to relevant personal memories. Some compared the prayer nut to modern objects with which we engage such as toys, cell phones, and jewelry. One participant made the following statement during the interview: "It is really a fun and an enchanting idea to me, to think of little worlds contained in small things, and I guess that was the appeal of toys that I grew up with, like Polly Pocket and Mighty Max, which is a boy version. I loved them a lot and played with them a lot." The ability to relate to the prayer nut with one's personal memories and experiences also helped identify the meaning and value of the artifact: "I was really having this intimate moment with this object, which I think is what these objects tend to be about. They are personal." These statements show that encountering and handling artifacts with multiple senses can offer new routes to making personalized connections with different times and cultures.

(3) Limitations of the Prototype

There were limitations on the design of the prototypes and sensory interaction. Due to the lack of resources, the prototypes were 3D printed through plastic, which lacked in detail although they were made in a similar size to the originals. Participants reported that they wanted the interface to retain the look and feel of the actual artifact. They additionally speculated that a replica that resembles the weight and texture of the original more

closely would have enabled them to immerse themselves in their sensory interactions without getting distracted by the poor quality of the prototype.

Rather than providing three separate prototypes, participants suggested providing a single prototype with all three functionalities, similar to how the original artifact was made and used. Combining the three prototypes in one can enable participants to explore freely the original uses of the artifact in multiple ways, through which interaction they can gain in-depth knowledge. These suggestions highlight the potential for redesigning replicas that would be more credible and would offer diverse uses. Since firsthand experience can be reinforced or distracted through the transparency of the interaction design, the prototype can be redesigned for a more robust and versatile interactive experience.

5.2.7 Summary

The two case study projects revealed that narrative and embodied interaction with artifacts supports sense-making because it helps contextualize the meaning of the interaction through cultural perspectives. The designs of the *Mapping Place* and the *Multi-Sensory Prayer Nuts* resulted in interactive systems that leverage embodiment to engage with cultural heritage. The *Mapping Place* project highlighted meaning-making through creating story-maps and the *Multi-Sensory Prayer Nuts* highlighted empathizing with a religious activity through a first-person multi-sensory experience. Evaluating the *Mapping Place* project shed light on the importance of priming interactors about the perspectives of the people who used a cultural artifact in its actual setting. The *Multi-Sensory Prayer Nuts,* which was designed based on our findings from the *Mapping Place,* provided further sensory engagement. The participants reported that being able to

handle the prototypes of the *Prayer Nut* prompted them to make associations with the past, and the multi-sensory cues assisted them in grounding their narrative interpretations in the prayer nut's original cultural context. Thus, the *Multi-Sensory Prayer Nuts* project suggests the potential for tangible and embodied narrative interaction to support sense-making of the context of artifacts in museums.

CHAPTER 6. DISCUSSION

This chapter shares lessons learned from the design, development, and evaluation of the two case study projects and the *Tangible and Embodied Narrative Framework*. These lessons in turn contributed to generating design considerations for designing interactive interfaces to display artifacts in cultural history museums. Below, I discuss the lessons learned, revisit the framework, and share the design considerations for presenting cultural artifacts with digital media.

6.1 Lessons Learned from the Case Studies

Interaction with cultural heritage can be challenging since the interactors come from different backgrounds, thus increasing the likelihood of failure to make meaning out of their firsthand engagement with such experiences. Without knowing the background and context, the interactors would not be able to make authentic meaning of their interactions and would have difficulty aligning their expectations with the outcomes. Thus, it is important for interactions to be grounded and interpreted within the appropriate cultural context. The following sections present the design challenges posed by the case study projects, analyze the consequences of design by using the *Tangible and Embodied Narrative Framework*, and share ways that the framework can be extended.

6.1.1 Designing for Cultural Heritage

The main lesson for designing interactions that we learned through the *Mapping Place* project is the importance of priming interactors for meaning-making. While we attempted to establish the interactor's narrative engagement with the *Mapping Place*, the

misinterpretation came from the fact that the interactors came from cultural backgrounds different than that of the artifact. This mismatch of backgrounds hindered the interactors' reception of the cultural concept we had intended to deliver through their interactive experience. The interaction was taken out of context because the interactors did not know the meaning of their interaction with the tabletop. While our design assumption was that tangible interactions would be transparent enough to reveal the underlying cultural concepts, participants' evaluation of the *Mapping Place* project clearly showed that interactors should understand the cultural concept first in order to apply their knowledge to their interaction with a cultural artifact.

The *Multi-Sensory Prayer Nuts* highlighted that tangible and embodied interaction may bridge the gap between different cultures and assist in interpreting artifacts from the point of view of an artifact's originating culture. The evaluation of the project showed that first-person experience within a narrative situation may support personalized connection and contextualized interpretation of the artifact. Specifically, the interaction that offered an internal and diegetic experience helped interactors imagine themselves being the actual person using the prayer nut in the 16th century in the Netherlands.

6.1.2 Advantages of the Diegetic vs. Non-Diegetic Axis

The *Tangible and Embodied Narrative Framework* proposed in Chapter 4 can serve as an analytical tool to make better design decisions. The *diegetic* vs. *non-diegetic* axis, which I added to the *internal* vs. *external* and *ontological* vs. *exploratory* axes in Ryan's framework, informs how to meet the design challenges posed by the case studies discussed above. While both case studies offered narrative engagement to reflect on a

cultural artifact and practices surrounding it, the different design choices led interactors to different forms of engagement and different avenues for reflection. By positioning the interactor to have an external, ontological, and non-diegetic experience, the *Mapping Place* project enabled interactors who had attended the ten-minute lesson before the interactive session to apply the abstract concepts they had learned. Performing actions to construct stories was thereby the main method of sense-making in the *Mapping Place*. Different from the *Mapping Place*, the *Multi-Sensory Prayer Nuts* required interactors to identify with a fictional character to discover and find meaning through *internal, exploratory,* and *diegetic* narrative experiences.

Mapping the two case study projects on the proposed *Tangible and Embodied Narrative Framework*, together with the evaluation results, leads me to speculate that certain combinations of the design axes provide different means of reflection. The *external* and *non-diegetic* interaction seems to prompt interactors to reason abstract concepts and the *internal* and *diegetic* interaction seems to have the interactor walk in the shoes of the original people who used the artifact and, thus, to empathize with them. However, this speculation may need to be further evaluated through additional tangible narrative projects, like those shared in Chapters 3 and 4, in order to be able to make a more generalizable argument.

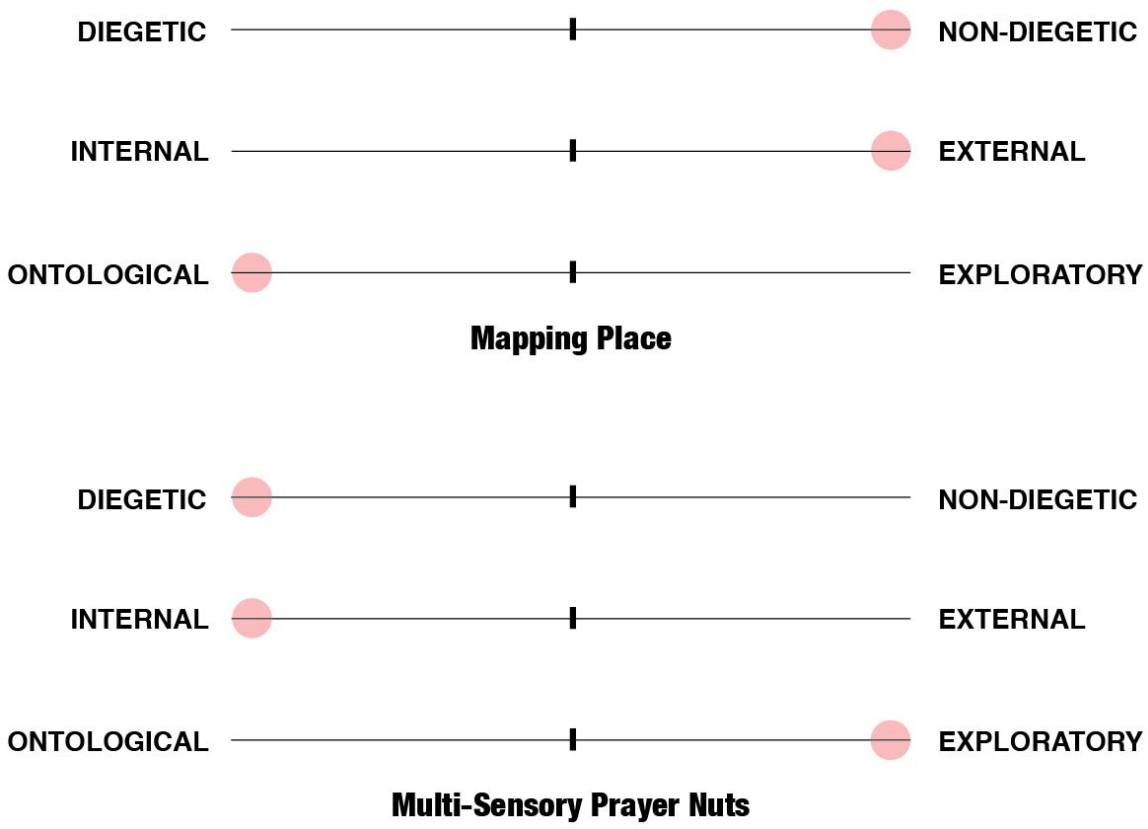

Figure 30. Mapping the case study projects using the *TENF*

The *TENF* can also be used to identify how the design of *diegetic* or *non-diegetic* interactions may assist with *internal* or *external* interactions. The *diegetic* interaction in the *Multi-Sensory Prayer Nuts* project reinforced the embodiment of an *internal* narrative perspective by enabling the interactor to make gestures similar to those the actual user of the prayer nut would have made. Similarly, it further motivated the interactor to discover more diverse interactions and different ways the prayer nut was used. This intersection of experiences suggests that tangible and embodied interaction may support the embodiment of narrative perspectives. Additional projects and studies need to be conducted to identify the consequences and challenges of *diegetic* or *non-diegetic* designs. We can surmise that interactive designs to communicate cultural heritage can benefit from a holistic approach,

where narrative and embodied interaction can guide and add meaning to the interactor's experience. A narrative can support grounding interaction within cultural concepts and perspectives, while embodied interaction that is *diegetic* or *non-diegetic* may reinforce taking *internal* or *external* narrative perspectives. Therefore, a tightly coupled narrative and tangible interaction can better support sense-making.

6.1.3 Moving Forward with the Framework

The design, development, and evaluation of the two case study projects (see Chapter 5) gave insight into further uses of the proposed *Tangible and Embodied Narrative Framework*; namely, that it can assist designers and researchers in (1) tracking the fluctuating experiences of the interactor within a spectrum and in (2) generating interactions in a new project. The three spectra – *diegetic* vs. *non-diegetic*, *internal* vs. *external*, *ontological* vs. *exploratory* – are intended as a scale, although they were utilized as a binary to map relevant projects in Chapter 4. In future work, they can be further developed to show degrees to which a project may be more *diegetic* than *non-diegetic*, or less *internal* than *external*, etc. (see Figure 31). These degrees can be mapped as points on a scale between the opposite ends of each spectrum and can guide not only the analysis of various interactive experiences, but also their design.

6.1.3.1 Tracking the Fluctuating Experience from the Interactor's Point of View

The *TENF* can be used to view the three spectra as a nuance or a continuum of interactions fluctuating throughout the interactor's experience with a tangible and embodied narrative system. In this case, the interaction is not fixed to a particular point or

degree by the way the designers/researchers determined it, but fluctuates depending on the various ways that the interactors relate their tangible and embodied interaction to a narrative. That is, an experience can move from one point of the spectrum to the other throughout an interaction, enabling designers/researchers to use the framework as an observation method. For example, an experience can be mostly *diegetic* but may include some *non-diegetic* experience, and vice versa. In the *Mapping Place* project, the *non-diegetic* interaction prompts interactors to think through their own experience at the present time as they are interacting with the interface, while the *diegetic* interaction supports them to also reflect on the original context of the artifact. In other words, the interactor's experience can begin as being *non-diegetic* when the he or she is unable to relate his or her experience to narrative consequences, and it may later move toward being a *diegetic* experience, as the interactor makes a connection between his or her embodied experience to the narrative consequence. This interpretive slippage may lead designers of museum projects to think more about how to include both *diegetic* and *non-diegetic* experiences within an interaction.

6.1.3.2 Generative Method from the Designer's Point of View

The *TENF* can also be used by the designer to view the three spectra as a fixed point or a degree for generating specific types of interactions on each spectrum. Certain interactions may have a stronger or weaker form of the *diegetic* or *non-diegetic, internal* or *external, ontological* or *exploratory* experiences, as shown in Figure 31 below. For example, interacting with a tangible puzzle may be identified as a stronger degree of *non-diegetic* interaction, compared to a multi-touch tabletop interaction displaying a map of the narrative environment.

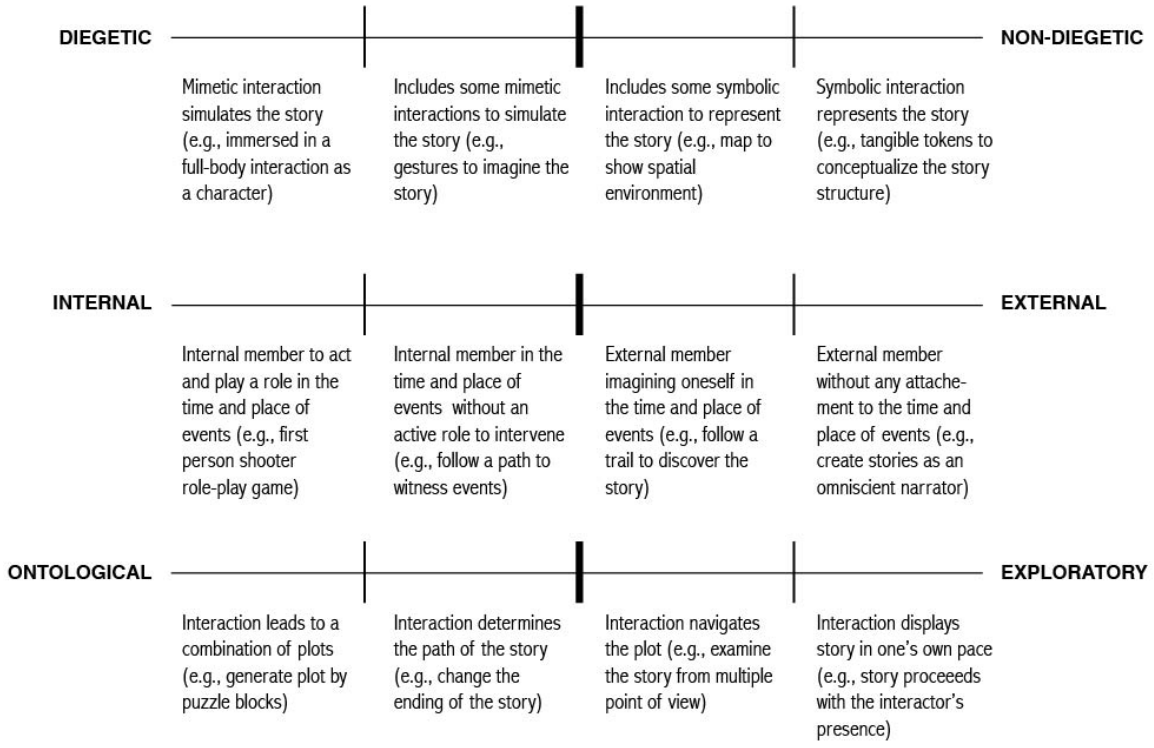

Figure 31. Mapping the specific degree of interaction on each of the three spectra

6.1.4 Summary

This section presented the design challenges the case study projects posed; it analyzed the consequences of design by using the *TENF* and; it shared ways that the framework can be extended. As the design for cultural heritage can be challenging since visitors come from different cultural backgrounds, the *diegetic vs. non-diegetic* spectrum in addition to the *internal vs. external* and *ontological vs exploratory* spectra in the framework has the potential to provide ways interactors can engage physically with the narrative environment. The *TENF* also has the potential to cater to designers and researchers' specific needs in the process of generating new tangible and embodied narrative interactions.

6.2 Design Considerations for Engaging with Cultural Heritage

Designing case studies and evaluating them through the theoretical framework provides insight into the design of tangible and embodied interactions for cultural heritage. Below, I elaborate on the design considerations to support such interactions. These design considerations – (1) design process, (2) design of embodiment, (3) design of narrative, and (4) development – are generated primarily through contemplating the consequences and challenges of the design decisions we made for the case study projects. They can guide designers toward creating tangible interactions that interactors can undertake to learn about an artifact through its specific cultural context.

6.2.1 The Design Process

(a) Research tangible and embodied interaction grounded in the cultural dimension of the artifact

Research broadly within the interaction context and the who, what, when, and why of the cultural practices associated with the artifact in its original context. Focus on original users' gestural or sensory practices with the artifact, which could have a metaphorical meaning and value added to it. Do not simply reinterpret the object's meaning; take special care to consider how the original users interpreted their practices associated with that object. Discussing and planning with cultural leaders may be necessary to truly understand the original meaning. Throughout the design process, it may be necessary to revisit the original use of the artifact to ensure that the cultural dimension is not altered or altogether overlooked.

(b) Consider collaborative or communicative dimensions of the artifact

It is not necessary to design for a collaborative interaction, but the museum space offers opportunity to collaborate. The collaborative or communicative dimension of the artifact can be easily translated to a corresponding interaction design to promote conversation among visitors. The interactive experience can function as a mediator to promote conversation surrounding an issue, or can require role-play involving multiple visitors, or become a platform for co-creating user-generated content. However, if the artifact contains personal and meditative value, it may be difficult to encourage a collaborative experience.

6.2.2 Embodiment Design

(a) Brainstorm embodied actions

Brainstorm embodied gestures through which interactors can engage with an artifact. Rather than being constrained by the form of the artifact, envision its usage in its original environment which can help design a digital facsimile of the original. Consider the practices and gestural and sensory interactions that the original users may have performed with the artifact. Brainstorm actions or gestures (e.g. pointing, dragging, holding, shaking), sensory experiences (e.g. smelling, touching, hearing), and pair them with symbolic meaning or cues (e.g. mnemonic practices, meditation, passage of time) associated with the artifact.

(b) Seek inspiration from cultural forms and practices, but do not be limited to creating a replica

Cultural forms and practices can provide guidance toward designing an interface that can prompt interactive experiences in users. Interfaces that adhere to the cultural forms or practices associated with the artifact can support interactors with drawing connections between their interactive experiences and the original artifact. However, that does not necessarily mean replicating the experience exactly. The shape, size, color, texture, material, gesture, or sensory experiences (e.g. smelling, touching, shaking, flipping, holding) can be retained from the original or they can be redesigned in combination with digital effects. A digital experience with the interface may be designed to represent cultural practices. As seen in the *Mapping Place* project, the action of placing a shell on the multi-touch tabletop is representative of an action of arranging beads and assigning meaning to them on the *Lukasa* board.

(c) Select interaction modalities in a narrative environment

Analyze the artifact or practices to determine the aspects of how to design interactions. If the artifact embodies a unique and unfamiliar meaning that is difficult to grasp, designing for a non-diegetic experience may be necessary to help interactors comprehend the underlying meaning of the artifact. If an artifact has been utilized in a specific situation that needs to be communicated to help interactors understand the value of that artifact, a diegetic experience may be appropriate to provide an immersive interactive experience, with empathy for the original users of the artifact. Once the interaction modality is determined, select the technology and interface that is appropriate for the chosen *diegetic* or *non-diegetic* interaction. For example, a virtual reality interface can be appropriate for a *diegetic* interaction to provide a first-person experience. In contrast, a tabletop interaction can be appropriate for a *non-diegetic* interaction.

(d) Extract gestures and tangible objects that can be sensed

Design embodied interaction with artifacts that can be sensed. Benford et al. (2005) have shared the importance of designing interactions that clearly communicate the technology for sensing so that interactors do not have false expectations of the interface. They have argued that it would be ideal if the shape of the interface manifested the method of interaction or sensing. However, my design experiences with the *Mapping Place* and the *Multi-Sensory Prayer Nuts* indicate that designing interactions with cultural heritage artifacts that are unfamiliar to interactors can be challenging, since a simple and easy-to-grasp design would be required to help interactors understand what is expected of them. Visual or audio cues can be combined with sensory feedback to promote the intended interactions. For example, since breathing can be difficult to sense, alternative means of detection can be used, such as sound, temperature, or touch. Therefore, to stimulate the interactor to inhale, a wind sound can be added.

(e) Integrate physical interaction and digital feedback

Physical forms can be utilized to engage interactors, and digital feedback can be added to follow up and provide additional information. Cultural forms and gestures can provide entry points for the interactor, with which to engage content from a cultural perspective. Once the interactor is engaged, digital feedback can be added to motivate further interaction and to provide corresponding information. For example, a tangible object on a multi-touch tabletop, such as a story-shell in the *Mapping Place,* can be an entry point for engagement. Once the story shell is placed on the table, the story categories on the surface of the table prompt visitors to create stories. In these ways, the integrated physical

and digital forms can be utilized to recreate cultural experiences and evoke thoughts about the original practice.

6.2.3 Narrative Design

(a) Establish narrative perspective and roles for the interactor

Select a perspective and role for the interactor to engage with the narrative environment. The nature of the content, the physical artifacts in question, their original setting such as time and place in history, the ways in which they were used, the types of stories that people tell with or about these artifacts: these are all components that will help designers think about possible narrative perspectives and roles. If the artifact provides unique sensory experiences or strong emotional content that can be understood by having a first-person experience, an internal narrative position may be appropriate. For example, the *Multi-Sensory Prayer Nuts* offers a multi-sensory experience during one's religious practice with the prayer-nut through positioning the interactor into a hypothetical user, such as a merchant in 16th-century Nethertlands. If the artifact provides elements that can be examined or reassembled, or if it requires understanding a broader point of view in time or space, an external narrative position may be appropriate. Assigning clear roles may assist with grounding the interactor in specific perspectives; however, the interactor may resist assuming a role. An ambiguous role such as that of an omniscient narrator may be comfortable for the interactor to assume, yet it may not be appropriate for empathizing with the cultural dimension that the interactive system is designed to communicate.

(b) Design the interaction trajectory as a journey to the original cultural context

Consider interaction with the interface as a journey back to the original cultural context, which will likely be unfamiliar. Design the interaction scenario to provide an entry point that engages the interactor, to keep him or her interested. For example, in the *Mapping Place*, the tangible object (story-shell) may raise one's curiosity, and the desire to construct a story map can be the motivation to keep interacting. The design of *ontological* or *exploratory* interaction, or guided or open-ended interaction can depend on the specific types of information that need to be addressed and the design strategy to reveal information. Offering more freedom with open-ended interactions can support constructive experiences where visitors can apply their knowledge of the learned concept. In contrast, a guided, step-by-step interaction may assist interactors in learning how the artifact was used. If the artifact entails various usages, designing tangible interaction that can support multiple entry points – rather than having one entry point that instigates a fixed interaction scenario – may leave interactors freer and cater to their particular interests.

(c) Utilize sensory (audio-visual) cues to provide contextual meaning of interaction and trigger imagination

Provide audio-visual or other sensory cues that contain contextual meaning about the interaction, such as what it would be like to perform cultural practices. These cues can also suggest proper ways to make gestural or embodied interactions as mentioned under Embodiment Design above. While the novelty of tangible and embodied interactions with an artifact may be interpreted in diverse ways, combining such an experience with audio, video, or sensory cues may support grounding the interpretation somewhere closer to the original context of the artifact. For example, in the *Experiencing Spirituality* prototype of

the *Multi-Sensory Prayer Nuts* project, the screen shows a hand holding a prayer nut and an audio of breathing in and out is played to prompt interactors to perform similarly. Furthermore, these cues can provoke imaginings that relate to the original practices, which can assist with meaning-making. At the same time, giving too many cues or literal illustrations may limit an interactor's imagination.

(d) Provide guidance and preparatory tasks

Since the interaction may be unfamiliar to interactors, one of the design suggestions would be to design introductory interactions or tasks to ensure that the interactor knows and is embodied within the role he or she is playing. Consider providing preparatory tasks to prepare interactors for engagement in addition to providing supporting texts or a video to inform them about how to engage with the interface. For example, similar to a game that allows interactors to try out a game before actually playing it, the interactive experience can provide an opportunity to also try it out before fully engaging with digital experience of a cultural artifact. Exploratory interactions, which do not change the ending, can be designed and offered as preparatory tasks to prime interactors about the original cultural perspective before they engage in an ontological interaction.

6.2.4 Design Development

The design for the interactive narrative experience should be an iterative process to ensure that (1) the narrative, (2) embodied interaction, and (3) digital media are integrated into a holistic experience for the interactor. Since the novel interactions may not be immediately clear to the interactors, usability testing would be necessary to evaluate and make design decisions. The effectiveness and impact of the design decisions

can be evaluated through observations and interviews with the study participants in the process of usability testing. As the users may not interact with the interface the way the designers intended, the process of iteration and revisiting the design will lead to design improvements and suggestions for future work.

6.3 Conclusion

The design of the two case study projects focused on designing interactions that support interactors' reflections on the meaning of cultural artifacts. Through these case studies, we learned that since artifacts represent a different culture than those of the interactors, it is important for interactions to be grounded in the cultural setting of the artifact, thereby interpreting it based on its original context. Creating a contextualized design of interaction can enable visitors to make sense of the cultural dimension of an artifact or an installation by interacting with it. This means two things: one, that sense-making activities should be designed based on the cultural dimension; and two, the design should be such that it assists interactors in interpreting the meaning of an artifact based on its cultural context.

CHAPTER 7. CONCLUSION

This dissertation presented research that proposes potential design methods for tangible and embodied interaction to engage museum visitors with the narrative of cultural artifacts. Chapter 7 concludes the study by answering the research questions, reviewing the research contributions, and making recommendations for future research.

7.1 Revisiting the Research Questions

This dissertation research aimed to answer three research questions. The first research question was: How can concepts of embodiment help us think about interactive narrative engagement? To answer this question, I examined the literature on interactive narrative and embodiment and researched existing tangible narrative projects. I found that embodied interaction with narrative can engage the interactor within the narrative environment represented by an interface, thereby associating the interactor with a narrative role and evoking narrative interpretations.

My second research question was: How do tangible narrative systems integrate digital media and embodied experience to provide narrative engagement? To answer this question, I collected examples of non-museum and museum tangible narrative projects and proposed the *Tangible and Embodied Narrative Framework* for analyzing and mapping out the design space. Mapping tangible narrative projects using the proposed framework describes various types of interactive narrative engagement through the axes of *internal vs. external, ontological vs. exploratory,* and *diegetic vs. non-diegetic*. I found that the addition of the *diegetic vs. non-diegetic* axis enables the designer to design an

interface that can engage the interactor with the narrative through sensory and embodied knowledge. This addition allows for embodied interaction with artifacts and enriches interactors' understanding of those artifacts.

My third research question was: How can tangible and embodied interfaces and interactive narratives be combined to engage visitors with the cultural context in museum installations? To answer this question and to demonstrate the design space that can be achieved through the *TENF*, I designed, developed, and evaluated two case study projects: the *Mapping Place* and the *Multi-Sensory Prayer Nuts*. These projects provided tangible and interactive narratives for visitors to interact with an artifact within its cultural context to gain knowledge and to contextualize the meaning of interaction from a cultural perspective. I found that hands-on experience with an artifact can enable museum visitors to form a connection between their own experiences and the cultural practice represented by the artifact. Reflecting on the evaluation results through the *TENF*, I proposed design considerations to create a holistic design of an interactive system with narrative using the *TENF* to support sense- and meaning-making of an artifact based in its cultural context.

7.2 Contributions

The findings of this dissertation research make the following contributions to the field of digital media: (1) provide a framework for interaction with cultural heritage, (2) allow a narrative-based analysis of tangible interactive systems, and (3) offer design considerations.

7.2.1 Framework for Interacting with Cultural Heritage

I reviewed existing interfaces in cultural history museums that attempt to display and provide knowledge about a historical artifact, which led me to design the *TENF*. In addition to the *internal vs. external* and *ontological vs. exploratory* axes included in Ryan's (2006) framework, the framework I propose in this dissertation, *Tangible and Embodied Narrative Framework (TENF),* includes a *diegetic vs. non-diegetic* axis. *The TENF* identifies museum or non-museum projects within the *diegetic* or *non-diegetic* axis*,* depending on whether or not the interactor utilizes his/her body to act on or explore the story events in an immersive environment. It thus contributes a new map of the design space that includes digital media for tangible and embodied interaction with the cultural context of an artifact. This framework expands and enriches the interaction with cultural heritage to consider its narrative impact on interactors.

7.2.2 Narrative-Based Analysis of Tangible Interactive Systems

Mapping museum and non-museum projects using the *TENF* allows for making a narrative-based analysis of interactive experiences that museum visitors can have. This analysis provides insight into the use of digital technology for narrative engagement. Mapping the projects using the *TENF* shows how various digital technologies for tangible and embodied interaction are integrated with narrative. A narrative-based analysis can help in comparing museum and non-museum interfaces and engender more possibilities for museum displays of historical artifacts.

7.2.3 Demonstration of the TENF through Two Case Study Projects

The case study projects offer two demonstrations of how the *TENF* can be applied to design and develop interactive engagement with different cultural heritage contexts. These interactive tangible narrative systems show how offering narrative engagement through tangible and embodied interactions in different ways support reflection on an artifact's context and design from culturally specific perspectives. By providing a framework for creating such work today, I hope to inspire designers of museum experience to evoke tangible and embodied interactions with cultural artifacts using innovative digital technologies.

7.2.4 Design Considerations

The design, development, and evaluation of the case study projects contribute to a better understanding of the important design challenges that must be considered in representing culture. These design considerations provide guidance to create a holistic design of an interactive system with narrative using the *TENF* – that is, how to ground interactive experiences in cultural perspective or how to represent interactive embodied experience correctly when the artifact has been removed from its original cultural context. The design considerations suggest integrating embodied interaction, narrative, and digital media. They provide digital media designers with tools for approaching the design of interfaces that prompt interaction.

7.3 Recommendations for Future Design and Research

I can conceive of several future research projects that I myself would like to carry out beyond this dissertation. Extensions of my dissertation study would include exploring other types of digital media and different combinations of axes from the framework.

Another extension would be to expand the framework to include more than three axes. Yet another project would be to test the *TENF* in an actual museum space. Finally, it would be informative to implement the *Multi-Sensory Prayer Nuts* project in a museum and track its reception in order to make adjustments and improve its design. Below, I discuss each of these options.

7.3.1 Explore Other Types of Digital Media

Future research could include exploring other types of digital media in the domain of interaction design for cultural heritage. Technology that enables interactive experiences in museums is widespread. Technological development enables new types of experiences, for example, VR/AR and wearable technology that are opening up new dimensions toward immersive narrative experiences. Open-source model software allows museum designers to prototype and custom-tailor the available software and hardware to meet the goals they have for various projects. For example, Computer Vision such as (Community Core Vision (CCV) allows for designing and developing interactive tabletops and surfaces. 3D printing technology that is getting more affordable and Microprocessors like the Arduino board allow designers to devise their own interactive systems with smart objects that can be utilized as physical tokens, puzzle pieces, etc. In addition to 3D printing technology, the Smithsonian Institution offers 3D digitization of artifacts (Smithsonian X 3D) that suggest the potential for including 3D printing and Maker Culture (a DIY movement) to engage with cultural heritage.

While there is potential for applying these new technologies to interactive experiences, this advancement requires considering the narrative interaction scenario and investigating

its impact for meaning-making. There are still much undiscovered possibilities for tangible and embodied interaction that museums can provide through the use of the latest advancements in digital technology for manipulating tangible objects and interacting with them. Mapping prospective projects using the theoretical framework through the axes of *internal vs. external, ontological vs. exploratory,* and *diegetic vs. non-diegetic* may enable identifying new design considerations for domains that have not yet been explored.

7.3.2 Expand the Framework

Moving forward, future research can expand the *TENF* to describe a how interactors can create stories in addition to how they can represent them. The *TENF* focuses on representing cultural artifacts and enabling interactors to relate to the cultural context of those artifacts. With museums offering creative spaces for visitors, an additional, fourth, spectrum may need to be identified to describe the process of story-making. In particular, numerous cultural heritages originate from craft practices; digital technology can augment these practices to track the cognitive and emotional processes they require, and disseminate or redefine them through visitor participation.

7.3.3 Implement the TENF in a Museum Space

Finally, I would like to publicize the *TENF* design proposal among cultural heritage museum professionals. While the proposed framework and case study may provide inspiration to museum professionals, it is important to consider questions such as, Is this type of interaction feasible to design given a museum's budget, space, and time? and Would such a design align with the goals of museum stakeholders? In an effort to better

integrate a design proposal into existing museum systems, some researchers argue for a co-design process with museum professionals through the design of interactive technologies (Marshall et al. 2016). Future designers can revisit the *TENF* together with museum curators and identify its value and or limitations in reference to creating a new installation for the museum space.

7.3.4 Implement the Multi-Sensory Prayer Nuts in a Museum Space

Alternatively, a future research project could examine the installation of the *Multi-Sensory Prayer Nuts* project in an actual museum space. Evaluating the project in a museum with real visitors interacting with the installation would suggest different findings from the current study which was only conducted in a lab setting. Observing visitors' interactions and interviewing them to learn their responses to the installation would reveal consequences of the design decisions based on the *TENF:* that is, whether and to what extent visitors were able to embody and interpret the intended narrative role.

7.4 Closing Remarks

The above potential future studies are some of the research projects that can follow up on my current research. This dissertation contributes to engaging museum professionals, designers, and communities of theorists and practitioners in interactive narrative on the topic of digital technology in cultural heritage. Such interdisciplinary collaboration has the potential to enrich outcomes, such as interactive narratives and cultural heritage in exciting and unexpected ways. It is my hope that the current study will inspire designers to broaden the types of interactive experiences provided in cultural heritage museums so that visitors can engage with installations viscerally. This new direction toward more

complex interactive designs can transform future museum installations to be even more experiential, participatory, and cognitively intriguing.

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